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Los Angeles Aqueduct Power The design and construction of a long aqueduct through forbidding country offer a great variety of intricate problems, but when to the primary function of water supply are added hydroelectric development and irrigation the problems are greatly increased in number and complexity. As is well known the Los Angeles Aqueduct is to serve these three purposes, but that statement unless further qualified fails to convey an adequate idea of the conditions limiting the designers, for the water-power will be so developed that the peak loads, though expected to be greater than the energy due to the normal flow, will, nevertheless, be supplied by the hydraulic stations instead of by steam auxiliaries. It is evident that this would involve either a waste of water or some method of storing tail water temporarily and feeding it back to the aqueduct. The latter solution was adopted. This required aqueduct cross-sections with capacities more than double the average, and storage reservoirs both above and below the stations—of which there will be seven in all, two handling the peak loads. The first station to be built is San Francisquito No. 1, described elsewhere in this issue. A number of features of its design are worthy of special note. The regulation of the water, which will be continually changing in amount, involved the building of a surge chamber of gigantic proportions over the end of the long Elizabeth tunnel at the head of the penstocks. The latter have some unusual features, in the use of heavy lap-welded and banded steel pipe.

Reference Data on Dredges A very large proportion of the urban population of the United States is located on or near navigable waters, and the problems of river and harbor improvements continually arising all over the country often come before engineers other than those connected with the Corps of Engineers of the army. It is notable, however, that the latest annual report of the chief of engineers is the chief reference when an engineer undertakes to bring up to date his knowledge of dredging and comparative methods and costs. Indeed, if a study of operating data and a comparison of various types of dredges is contemplated it would be hardly possible to find another source of information so reliable and so broad in scope. Nevertheless, it is regrettable that in this branch of engineering there is, comparatively, so little information available for the use of engineers who have not had extensive experience with dredges. For example, if a bridge engineer were suddenly called upon for an estimate of the cost of driving a certain tunnel he could readily secure data on tunnel-driving costs, equipment and rates of progress. But if he were called upon for a preliminary report on certain harbor improvements, he could not so easily decide whether an agitator-suction or a scraper-suction dredge would be preferable for the work in hand, and how much it would cost per cubic yard to handle the material. The reason for this is, of course, that dredging work is planned and directed from a comparatively few offices, and few men outside the corps of engineers and contractors to whom the data are stock in trade are in a position to write comprehensively on the subject. An article published elsewhere in this issue affords a rare opportunity for readers of the Engineering Record to file for reference costs and operating data on several different types of dredges. These data have been compiled under unique conditions because the dredging fleet described, representing a layout of $1,200,000, has been operated on a scale only possible in government work, and still under the active direction of a single individual, Mr. H. A. Bayfield. By virtue of his interest in and familiarity with all details of the work, which resulted in a carefully kept system of records covering a period of several years, it has been possible to present in concise form the essential points of interest in the maintenance and operation of a diversified dredging fleet.

City Manager for Dayton Taking advantage of the opportunity afforded by the new Ohio constitution, Cleveland and Dayton have adopted new city charters, following the lines of more centralized responsibility, which has become the distinguishing note of progress in American municipal administration in recent years. The new Cleveland charter was reviewed in these columns on July 12, 1913, page 31. The Dayton charter, adopted last week, provides for the employment of a trained city manager, after the plan already put into effect in a number of American cities, including Staunton, Va., where the plan has been in use for some years, and Sumter, S. C. Dayton, however, is by far the largest city which has tried the plan, the population being estimated at 135,000. The type of government is of the modified commission form, that is, the city, nominally, will be governed by five elective commissioners, who will, however, have only legislative functions. They will employ a city manager in whom all responsibility will be centered. He will appoint the heads of the executive departments, in which all employees will be under civil service. The new charter includes among other features a provision for a scientific budget, a complete and systematic auditing of city accounts, the installation of a modern accounting system, the employment of a purchasing agent, the standardization of city supplies and the introduction of employees' time and service records. That Dayton should break away from the old ward-and-council idea and adopt the short non-partisan ballot and centralized authority, thus eliminating a host of petty elective officials, is not to be wondered at by those who know anything of the utter breaking down of the former city government under the stress of the flood disaster. Whether or not reports circulated during the dark days following the flood to the effect that the chief executive, who should have taken the lead in bringing order out of chaos, practically abandoned his office and remarked that he was going home to take care of his own family, is true or not it is certain that a strong authority was needed to care for the afflicted, preserve what semblance of order was possible under the circumstances and restore the sewage and water systems to service. Crises bring out the strength and weakness of city governments as well as of men. Galveston in her days of distress brought forth the commission idea, and now Dayton, after a similar harrowing experience, has decided upon a new municipal dress. Unlike Galveston, however, Dayton was able to find precedents adaptable to her own needs and was not obliged to break new paths in municipal reform.

Dangerous Bridge Floors Danger from fire in the floors of steel bridges is not generally considered imminent, but that it is possible and may be very serious is demonstrated by two instances recently reported in the Engineering Record—the damage to the Armour-Swift-Burlington Bridge at Kansas City and to the Harriman Bridge at Portland, Ore. In both cases the wooden floors are reported to have been ignited by sparks from locomotives passing beneath the roadway, though in the Harriman Bridge there are reasons for believing that the fire was due to other causes. Neglecting the cause, the fact that the roadways of these bridges did catch fire and were in large part consumed and that serious injury was done to the structural framework is convincing evidence that the danger must be considered in the design of these structures. In the Harriman Bridge the operating mechanism was also damaged. In both cases the renewals will doubtless cost many thousands of dollars, probably much more than enough to have provided a non-combustible floor in the first place. The indirect loss by interruption of traffic and navigation during repairs may also be very large. Moreover, loss of life, though happily absent in these cases, might easily occur from fierce and rapid fires on important bridge structures. The selection of the most satisfactory type of bridge floor is admittedly a difficult matter in many cases. Wood floors are often used on account of their low first cost, the speed with which they can be constructed and their light weight. Where they are not exposed to ignition from below or from electric wires they may be found suitable, but where flames may attack them or in inaccessible or hidden places they should not be considered. A steel bridge is like a steel building, incombustible itself but not fireproof. Its framework is not even partially protected from flames and may be damaged by combustible materials of any nature burning on or near it. It is, therefore, clearly necessary to eliminate combustible materials in bridges exposed to fire hazards. Many forms of solid flooring, including buckle plates, flat plates, troughs, ballasted platforms, and, by no means least, concrete and reinforced concrete are available. Most of them may be paved with macadam, brick, asphalt or even with wood blocks, for the latter would be in much less danger from fire if laid on concrete or steel plates, protecting the lower surface from sparks and flames and excluding the air required for combustion.

Use of Irrigated Lands Claiming as their authority the Secretary of the Interior statements have been made recently that 95 per cent of government irrigation projects are now in the hands of large owners. This is evidently a distortion of a carefully written statement handed out by the secretary in June in which he says that "over 95 per cent of the remaining 570,000 acres of all irrigable but unirrigated land is in private ownership." Mr. Lane was endeavoring to point out that there are very few irrigated farms now open to entry. He might have said that over 98 per cent of the land formerly public had been entered and less than 2 per cent of these lands are available for entry. The substitution in newspaper reports of the words "large owners" for "private ownership" completely changes the statement. There would appear to be a discrepancy between the actual condition of affairs and the general impression that the irrigated lands are not being used as they should be. As a matter of fact both are correct. Hundreds of thousands of acres, and possibly millions, have been reclaimed by private and public capital, but these lands are lying unused not because they are in the hands of large owners, but because the hundreds of thousands of small owners, homestead men and others, either do not have the capital or desire to use the land and are hoping to make money out of the sale of the land rather than of the crops. The Reclamation Service itself has provided water for over 1,200,000 acres, of which about 650,000 acres were irrigated and cropped in 1912 and 550,000 acres were not used. The small owners have been just as keen to speculate on the bounty of the government as the large owners, for human nature is the same whether a man owns a ten-acre farm or a thousand acres. If he thinks he can make more money by holding it and eventually selling it to a "sucker" rather than by working hard and cultivating it, he is apt to take the easier course. The great problem of both the Reclamation Service and private irrigation interests is to induce or force the owners of the lands to use them and this is perhaps more difficult than the building of the works and the solving of the legal obstacles, because some of the deepest lying tendencies of human nature must be opposed. Western irrigation developments have practically ceased because of the high prices of raw land, due to the speculative spirit, and of the low prices received for produce from the cultivated land. It is an anomaly that the highest-priced land in the United States, namely, irrigable or partly irrigated land, is producing on an average possibly the least amount in crop values compared with its possibilities. This cannot last long, but while it does it has a destructive effect on investments in irrigation works and on related irrigation operations.

Purchasing Portland Cement on a Bonus System

As those who are acquainted with the history of the cement industry in this country know, the proposal to purchase cement under a bonus system of one sort or another is not new. Nevertheless the effort to raise the quality of all materials of construction is commendable and the particular form of bonus system proposed by Mr. W. C. Reibling, of the Philippine Bureau of Science, published elsewhere in this issue, therefore, deserves consideration.

Bonus systems previously proposed have generally been designed to secure greater fineness. For example, at the meeting of the American Society for Testing Materials in 1900 Mr. R. K. Meade called attention to a clause used by Mr. Kenneth Hartley in his specifications, which, while not applying directly to the purchase of cement, nevertheless has an indirect influence. The clause read: "In case the cement used in the work should be ground to a fineness exceeding the standard specifications by more than 2 per cent through the 200-mesh screen, the contractor may reduce the amount of cement per cubic yard of the concrete by 3 per cent . . . for each increase in the residue retained on the 200-mesh sieve." In the paper itself Mr. Meade states: "It is the intention of the present paper to suggest that the fineness of Portland cement, or tensile strength when tested with sand, or both, be used as an actual indication of its commercial value." In the discussion which followed Mr. Robert W. Lesley pointed out that in old government specifications there was a clause providing for decrease in the amount of cement if an increased sand-carrying capacity were shown, but that this clause had been dropped.

The real difficulty in paying a bonus for increased fineness lies in the determination of what should be considered "fineness" as applied to a cement. It is now conceded that the percentage of cement passing a 200-mesh sieve is not a fair indication of "fineness." It is well understood that the so-called "flour" is of great value in the setting qualities; but considering two cements one having a larger percentage passing the 200-mesh sieve may not contain anything like as much flour as one having a lower percentage passing the same size sieve.

Until this question of fineness is better understood—until a more logical way of determining what is really meant by fineness is discovered and the value of exceedingly fine grinding demonstrated—the advisability of adopting Mr. Reibling's scheme is open to question. Undoubtedly very fine particles in the cement do give it the larger part of its cementing value, but if all of the cement were ground to flour there would be a greater tendency for it to flash when water was added.

The coarser particles do have a certain value. Just what it is and just what percentage of flour should be in the cement have not been determined.

Relative to the suggestion of giving a bonus for increased specific gravity, it is true that the condition of burning affects the specific gravity. It is also true, however, that the raw material used in the manufacture of a given brand affects the specific gravity, while certain raw products require far different temperatures of burning than others. To give preference to a brand of cement upon its specific gravity would, therefore, be unfair. Each brand will run at about a given specific gravity and the chief use to which this determination is put is to detect the variations in manufacture. If, for instance, a given brand runs at about 3.2 and should drop to 3.1 the investigator would become suspicious. This is clearly brought out in the United States Government specifications for Portland cement.

It is apparent, therefore, that the payment of a bonus on specific gravity would favor certain brands and would not necessarily result in advantage to the purchaser in securing a higher quality of cement.

The objections to the scheme proposed by Mr. Reibling may be summarized in his own words, for in the early part of his discussion he says: "In fact the results obtained from standard tests are so little understood that they do not enable us to arrange the various products in their true order of merit." This being granted the advisability of paying a bonus on such specifications is certainly open to question. Undoubtedly the discussion of such matters, however, and the investigations on which they are often predicated do aid materially in advancing knowledge of the art of cement manufacture. Similarly the reference of the autoclave cement tests to the committee on cement of the American Society for Testing Materials, as was done at Atlantic City in June, will stimulate studies as to the adequacy of the present soundness tests. For that reason the suggestion by Mr. Reibling will undoubtedly be received with much interest by engineers who follow improvements in cement.

Regulation of Street Openings

It appears that even in England, credited as it is, and justly too, with more stringent municipal administration than obtains in the United States, it has not been possible to prevent the tearing up of good pavements by gas, water and electric utilities, even though the surfacing has been down only a short time. A recent correspondent in the "Surveyor" protests against the wastefulness of this practice, pointing out that the results become the more serious financially as the character of pavement increases in quality and cost. He proposes that the engineers and borough surveyors discuss, first, the advisability of control by highway authorities, through Parliamentary powers, of the matter of road openings; second, the methods of restoring the pavements, and third, the methods of charging for the work. In his protest and suggestion the editor of the "Surveyor" heartily concurs.

It is possible that in some American cities practice with regard to street openings has progressed so far that our English professional brethren can take a leaf from our book. While various cities have given much thought to the problem very likely no regulations are more complete and effective than those adopted in New York City.

Previous to the laying of a new pavement all of the city departments and utility companies which have subsurface structures are notified and ordered to make such repairs, renewals and extensions of their mains, ducts and wires as will care adequately for their service for several years to come. Upon completion of the new pavement permits for openings are not issued for certain periods, depending upon a number of conditions. Where the pavement is in first-class condition the period is normally three years, but the necessities of the case and settlements or other defects in the pavement may shorten this period to a minimum of one year. Utilities which have disregarded the notices to care for their structures before repaving have been held off for long periods, being unable to show sufficient necessity to warrant the mutilation of a pavement in first-class condition.

Restoration of the pavement is governed by very definite rules and is executed under the eye of an inspector. In the first place no undermining is allowed, that is, the width of trench at the top must be as wide as the widest portion of the excavation, and the backfill must be placed with great care in thin layers, properly consolidated. Secondly, the concrete base must be cut back six inches beyond the edge of the excavation while the pavement surface itself must be cut back six inches farther. In this way bearing is insured upon the undisturbed material, minimizing the danger of cracking and settlement which would exist if the base and surface joints were over the line of excavation, and allowing in addition for some beam and arch action.

The cost of the work is borne, of course, by the department or the utility making the opening and to insure proper workmanship a bond equal to about double the cost of the pavement must be made out to the Bureau of Highways, the amount to be forfeited in case there is settlement or the restoration of the pavement is unsatisfactory in other particulars. Companies with extensive structures have bonds on deposit with the highway bureau aggregating as much as $50,000.

The building of tunnels through which mains and wires can be laid has been proposed in many cities and was thoroughly investigated by a commission in New York several years ago. After debating the question from all standpoints the commission reported adversely to the tunnel scheme. Its cost would have been very high and it was considered that under the stringent regulations now in force the nuisance of constant street openings can be considerably reduced and the satisfactory restoration of the pavement guaranteed.

The subject is an important one in municipal administration and many American cities as well, probably, as those in England could benefit by the adoption of measures along the lines which have proved successful in New York.

The Production Supervisor and Work Schedules

There is considerable disagreement as to the extent of the influence which efficiency engineering has exercised upon commercial, industrial and other enterprises. The results accomplished are in direct proportion to the ability and experience of those in charge of the work, for as might be expected the many charlatans who entered the field while the movement was in the height of its popularity some years ago were ill-prepared for the tasks they undertook. Now that the popular glamour has worn off, the work is on a more solid basis and those who will investigate the subject carefully and with an open mind will be convinced that the movement has had a marked influence on a wide variety of industrial, commercial and other activities.

These observations are occasioned by an item in the article on the "Organization of an Engineering-Construction Company" in last week's issue of the Engineering Record, in which the functions of the production supervisor in the drafting department of the Stone & Webster Engineering Corporation were briefly outlined. The direction of the drafting work is under the chief draftsman and his assistant, assignments are made by them and the responsibility for the correctness of the work is theirs. Responsibility for adherence to a prearranged schedule, however, is placed upon an independent authority—a staff officer, known as the production supervisor. Not being burdened by the endless conferences on details of design which consume much of the time of the chief draftsman and his assistant, the production supervisor is in a position to use every expedient to put the work through, to discover delays and to rush reinforcements to a squad which may be falling behind the schedule. Furthermore, since his duties relate to the time element he is naturally on the alert for all short cuts and time-savers.

The idea has, of course, been widely applied in industries of every sort and while on construction work the foreman has been essentially a production supervisor his efficiency has been decidedly increased by using some of the devices which the efficiency engineer has found indispensable for the production supervisor. Formerly the construction foreman relied largely on his experience to gage the progress of work and insure its completion on time. The better practice now is to prepare complete schedules and progress charts and to check against them daily the actual progress of the work so that emergency methods may be applied before the schedule is irretrievably shattered.

Coupled with the preparation of proper schedules is the analysis of all the factors entering specific operations—analysis applying not only to costs, but also to equipment and methods of operation. Nothing is quite so illuminating to the man whose chief concern is the getting of results as a detailed analysis, in figures or charts, of the operations he has supervised. They throw into relief both the good and bad practices in his management and enable him to raise the general level of the efficiency of his organization.

While the scheduling of work and detailed analysis were developed to a high degree of perfection in some lines before efficiency engineering became popular there is no question that the latter was instrumental in spreading knowledge of these devices to other lines of endeavor. There is still, however, much room for their application, and the interest taken in them even by commercial establishments—studying such apparently routine operations as stenographic and clerical work—indicates that they have a very wide range of usefulness.

False Economy in Engineering Construction

Engineers as a class owe it to their profession to diffuse among laymen whenever possible ideas as to higher standards in professional work. In the abstract this will readily be admitted, but unless instances are cited now and then to show that there is great need for a better understanding of the character and requirements of high grade engineering work ardor is likely to diminish and opportunities for service to the profession neglected. For this reason the Engineering Record brings up the much-worn theme of the false economy in neglecting to employ competent engineers.

In the Engineering Record of August 9 there appeared a letter from Colorado Springs citing an absurd proposal for the construction of a concrete bridge. A recent mail brings news of the failure of a small steel bridge in the South for which the town supervisors (or more likely the bridge company) drew the plans, the services of an engineer being retained merely to inspect the structure on completion and give it his approval. The arrangement, of course, was absurd, which was proved by three of the spans going into the river the day after completion. It appears, however, that the engineer, so called, had approved the structure—an indication that a man who would be retained under such circumstances is not worthy of confidence. One might expect that the concrete bridge above referred to would suffer a similar fate if built under the specifications quoted in this journal on August 9.

False economy of this sort, moreover, is not confined to any one class of engineering work. A good statement of the case, so far as water supply and sewerage systems are concerned, is to be found in the last report of the bureau of sanitary engineering of the Maryland State Department of Health. The report says:

"The search of this office for maps, plans and records of and information concerning the various water supply and sewerage systems of Maryland has shown that many such systems have been built without the engagement of proper engineering services; that in many cases both design and construction are defective; that a large proportion of systems have been built with very meager and utterly insufficient plans; that some have been constructed without any plans, this particularly being the case where the systems have been built in small sections; that in very few cases are plans changed or added to so as to become proper and complete records of the actual work built; and that in a number of places such plans and records as were made have been carelessly kept and have become lost or burned. In a number of places about the only information that can be obtained is by word of mouth, from the superintendent or some other town officer."

Commenting on this state of affairs the report enlarges on the false economy of the procedure, expressing in excellent manner the ideas so often reiterated in these columns. "The effort of many municipalities," it continues, "to keep down expenses on public works by getting along without the services of an engineer, or by engaging an engineer of inferior qualifications, is a short-sighted policy. The usual result of such a practice is the establishment of improperly protected or uneconomically operated water supplies and poorly designed sewerage systems which do not admit of inspection, are uneconomical in construction, unsatisfactory in maintenance and operation, and which create offensive conditions in the bodies of water into which they discharge. An experienced and capable engineer can not only institute sanitary, suitable and satisfactory water supply and sewerage systems, but can usually save a community, by economical designs, much more than the cost of his services. He will leave, also, in the town's possession full plans of the work and complete records for future reference. The value to the community of such information cannot be overestimated, particularly when connections, additions or alerations are to be made, or when street work of another character is to be undertaken."

The conditions described being granted the natural question is as to the remedy. Without a doubt state supervision, which is becoming quite common in water supply and sewerage work, will go far toward lessening repetitions of this false economy. The work of state departments should not be that of design, but merely of checking, criticising and approving or rejecting plans made by engineers and submitted to the department for approval. In some states supervision is being extended also to highway and bridge work.

There will undoubtedly be many cases, however, which cannot be reached by such supervision and the only remedy in these cases seems to be to raise the appreciation of the work of the engineer in the mind of the layman. In towns and cities of large size this is not very difficult because the magnitude of the work compels the authorities to demand some degree of ability from their engineering advisors, whether on salary or retainer. The small towns, however, are very difficult to reach for they do not, as a rule, number among their inhabitants engineers of competence who will use their influence to direct the town authorities. The correction of the abuse of false economy in these cases will come but slowly, but that should not discourage engineers from exercising what influence they can when brought in touch with the authorities or citizens of small communities.

Irrigation of Santa Cruz Valley—Part I

Recovery of Underground Water in Arizona by Wells and Pumps

By M. C. Hinderlider, M. Am. Soc. C. E., Chief and Supervising Engineer, Denver

There has recently been completed at Tucson, Arizona, for the Pima Land & Water Company, an irrigation system for the recovery and application of the underground waters of the Santa Cruz valley. While by no means unique, a number of the features of this project are nevertheless unusual.

With the exception of a comparatively few large rivers such as the Salt, Gila, Verdi and others of less magnitude, the principal water supply of southern Arizona is found underground. Many of the most noted examples of systems for the recovery of the underground waters are to be found in the Salt and Gila River valleys. Here the geological formation constituting the water-bearing material, is such that deep wells are obtainable. In other localities, such as the one with which this article has to deal, the water-bearing formation overlying the impervious subformation beneath the valleys is comparativley shallow. This condition, as will be seen later, made it necessary to depart from the procedure of development common to southern California, the Salt and Gila River valleys of Arizona, Texas and Arkansas, where the driven or bored well is extensively used.

Rainfall and Runoff

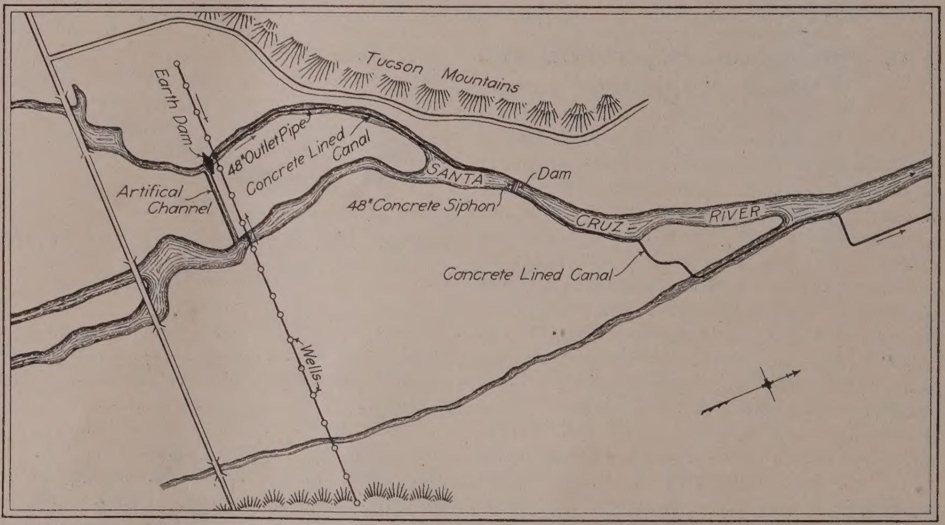
The Santa Cruz River has its source in the higher altitudes of southern Arizona whence it flows southward into Mexico. The course then is reversed, the river flowing back north into Arizona, past the city of Tucson, to its junction with the Gila River, about 70 miles north of the latter city. The flow of this stream is intermittent, surface discharge occurring only during the periods of excessive rainfall which occur in July, August and September, and to a smaller extent in December, January and February. At all other times the channel of the stream is dry. The drainage area of the Santa Cruz at Tucson is about 2100 sq. miles, while the average yearly precipitation over this drainage area, which is mostly mountainous, ranging in elevation of from 2500 to 900 ft. above sea level, is about 16 in. The yearly surface runoff at Tucson varies from 5700 to 28,460 acre-ft., the average for six years being 14,643 acre-ft.

Above Tucson the main valley of the Santa Cruz, as determined by the adjacent mountain ranges, is from 10 to 12 miles wide. The major part of this area consists of high, rolling plains, composed mainly of a hard cemented formation, locally known as "Caliche," which is practically worthless for agricultural purposes. The valley proper is from 1 to 3 miles wide and consists of a deposit of sand, gravel and boulders of varying thickness in the channels eroded through the "caliche" beds, over which has been spread a more recent deposit of silt of from 10 to 30 ft. in depth. This latter formation constitutes the agricultural lands of the valley, while the deposit of sand, gravel and boulders provides the medium through which the underground water seeps.

The gradient of the valley in the vicinity of Tucson varies from 15 to 20 ft. to the mile. The present channel of the Santa Cruz consists of a recent erosion from 100 to 300 ft. in width through the silt deposits overlying the water bearing gravels. This channel for miles above and below Tucson has been carried down to the water bearing sand and gravel, and now serves to collect and convey the flood waters entering the valley.

At the city of Tucson the valley narrows perceptibly by reason of the converging of the mountain range forming the western rim of the valley, and the "caliche" mesa on the easterly margin of the latter. At this point the valley proper is about 1 mile in width. From a study of the surface conditions it appeared that there would probably be found beneath the valley at this point an impervious stratum forming an underground barrier to the underflow causing the latter to rise to the surface. Further examinations also showed that the underflow of the Santa Cruz valley, which of necessity must pass this point, might be developed at this location and conveyed through an existing canal known as the Manning ditch to lands north and easterly of Tucson.

To verify previous assumptions as to the extent of the water supply and also for the purpose of securing data on the depth and quality of the water-bearing material under the valley in this vicinity, twelve test holes, 6 and 8 in. in diameter, were drilled across the valley at this point, practically at right angles to the course of the river. These test wells were spaced varying distances apart and were in each instance sunk well into impervious material. The distance drilled over covered 1 mile. All the material encountered was carefully sampled as the drilling progressed, a void analysis made, and a careful record of all results kept. For the determination of the velocity of the underground water numerous measurements were made by means of the Schlicter method.



Plan of Pumping District, Showing Location of Wells and Canal

Recovery and Distributing System

The recovery and distributing system, planned for an normal capacity of 40 sec. ft., consists of nineteen wells drilled in a straight line across the narrow part of the valley. These wells are connected by means of a gravity conduit of reinforced concrete, 4740 ft. in length, located and built from 5 to 12 ft. below the water plane of the valley. The distributing system consists of a reinforced concrete pipe line 48 in. in diameter, 1500 ft. in length forming the outlet from the recovery system, a 48-in. concrete siphon under the Santa Cruz River, about 7 miles of ordinary earth canal, 12,650 ft. of which are lined with concrete, and 21 miles of laterals of which about 3000 ft. are lined with concrete. In addition there are numerous reinforced concrete drops, provided with steel measuring weir, steel flumes, 1200 ft. of 24-in. concrete siphons under the Santa Cruz and Rillito Rivers, one earth and one timber dam across the former river, a large number of check and division boxes, lateral head-gates, drainage structures, etc., about 200 in number and common to most irrigation projects.

Probably the most interesting feature of this project and certainly the most important, is the recovery system of nineteen wells drilled across the valley to intercept the underground waters, together with the necessary pumping equipment and conduits for conveying the water recovered to the open canal system. The wells were drilled to various depths ranging from 45 to 150 ft. below the surface of the ground, each hole being sunk through the water-bearing material well into the impervious material below, the profile of which was found to be quite irregular.

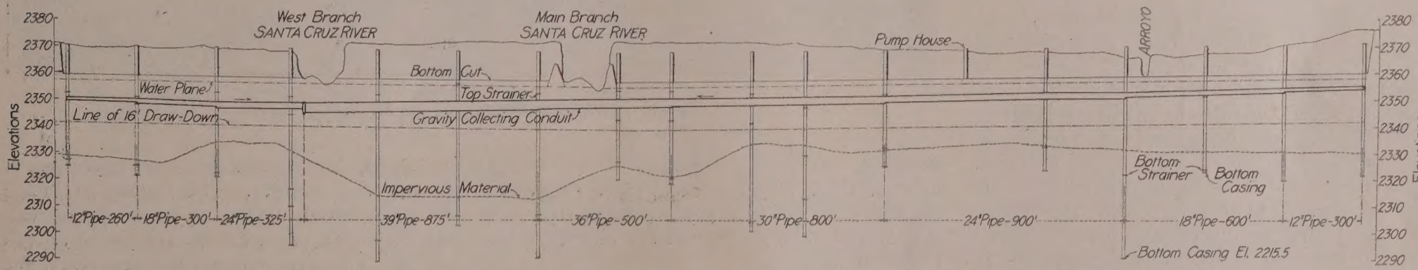
One of the accompanying illustrations shows the general plan of this development. It will be seen that at the point of drillings there are two channels of the Santa Cruz, the main channel being near the center of the valley at this point, while the west branch occupies a position near the western extremity of the valley and enters the main channel about ½ mile below, at the intake of the old Manning ditch, the control point for the distributing system. Since the recovery system is a combination of gravity flow and pumping, it became necessary to determine at what depth below the surface of the valley it would be most feasible to locate the collecting conduit connecting the line of wells. This point was determined by making a series of careful estimates of the cost of building the required conduit, pump-houses and sand traps at various depths below the surface, based upon the bids of reputable contractors and upon the writer's experience in such work. From these computations a curve was prepared showing the cost of construction for each foot in depth between the normal water plane of the valley and the limit of depth established by the intake of the Manning ditch.

In these considerations many additional conditions had to be considered—for instance, the depth below the surface and the varying length of the 48-in. outlet conduit, the grade and size of the open concrete-lined canal between the lower end of the 48-in. conduit and the 48-in. siphon under the Santa Cruz River at the head of the Manning ditch, grades for measuring weir, and first cost of pumping equipment. The necessary computations were then made, showing the yearly operating and fixed charge for a pumping system designed to meet the conditions imposed by placing the conduits, pump houses and outlet conduit at the various depths below the normal water plane assumed in the computations for first cost. In making the latter computations, consideration had to be given to the length of the pumping season, which was not only affected by the irrigation period during any one year, but also by the amount and length of run of surface or flood water in the Santa Cruz River, a portion of which is available for this irrigation system, the probable amount of water made available by each foot of draw down in the wells, and a number of other points of minor importance.

These computations having been made, the most feasible depth of location for the outlet conduit and hence the conduits connecting the wells, was determined upon. Fortunately the elevation of this point of outlet into the West Branch conduit coincided very well with the elevation required by the necessities of reaching the elevation of the Manning ditch some 3200 ft. lower down the river. The invert of the concrete conduit connecting the wells is from 4 to 12 ft. below the normal water plane of the valley, while the 1500 ft. of 48-in. outlet conduit in the West Branch of the river is built from 6 to 13 ft. below the normal water plane.

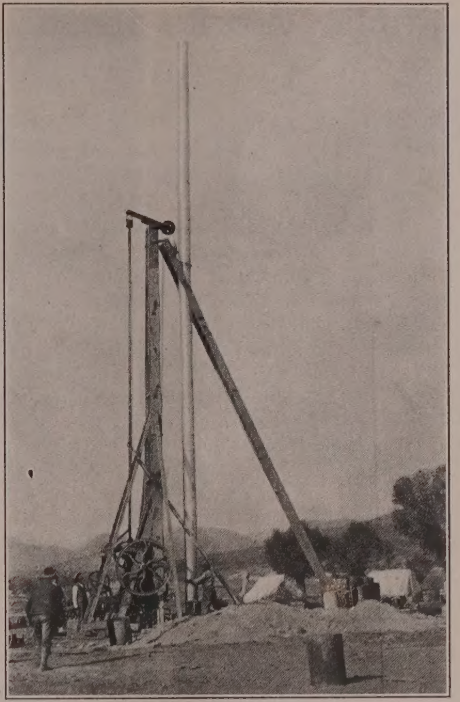
Wells and Strainers

Galvanized No. 8 gage perforated strainers 14 in. in diameter of various lengths form the finished wells and extend from the bottom of the pump houses through the water-bearing material into the impervious strata. These strainers were purchased in the form of galvanized perforated sheets, 46x60 in. in outside dimension. The perforations are long slots and with few exceptions are 3/16 x 1 in. in size. The perforations are staggered, providing a maximum of about 40 per cent of perforation. Around the periphery of the sheet there was left a blank margin of 1½ in. for rivet holes. These sheets were rolled and riveted at the local iron works into sections 60 in. in length, after which they were fitted together and riveted into lengths to suit the depth of well. The perforations in these well strainers were not slitted or punched so as to leave a burr on one side of the sheet, but were punched leaving a clean hole in the sheet. When rolled into the cylindrical strainer the total area of perforations available for the passage of water amounted to about 36 per cent of the superficial area exposed to the gravels. The wells varied in depth from 28 to 50 ft. below the normal water plane of the valley.



Line of Wells, Pump Houses and Gravity Collecting Conduit on the Santa Cruz Valley Project

Two wells were first drilled 100 ft. apart after which a pumping test was made. Tests made through 2-in. gas pipes spaced at varying distances on either side and above and below these wells showed that the draw-down curve produced by lowering the water to a depth to produce about 1000 gal. per minute would intersect the curve of the adjoining well and hence affect its output. Accordingly the succeeding three wells were spaced 200 ft. distance from one another. After these wells had been developed, further pumping tests were made to determine the extent of the draw-down curve. After study of these data, it was decided to space all other wells on 300 ft. centers. This plan was followed in the location of the other wells, except where the topographic conditions made it necessary to change this arrangement slightly. Further pumping tests seemed to justify this spacing, the idea being to space the wells so as to recover all the water passing down the valley, and yet not materially interfere with one another.



Well Rig and Strainer

Well Drilling Methods

Two rigs, with sand buckets of the bottom flap-valve type were used for drilling the wells. These sand buckets were 12 and 14 in. in diameter and of sufficient weight to crush and pick up all boulders encountered, no solid drill bits being used. To prevent caving, 16-in. double weight No. 12 gage stove-pipe well casing was used in each hole. The bottom of each casing was fitted with a starter consisting of 4 ft. of double thickness and 4 ft. of triple thickness No. 12 gage stove-pipe casing to which was riveted a forged 1x10x16 in. steel drive-shoe, acting as a cutting edge for the starter. Hydraulic jacks of 50 tons capacity were used to force the casing down as the drilling progressed and to draw the casing after the 14-in. strainer was inserted in the hole. Very little difficulty was encountered in drawing this casing up to depths of 100 ft. or more.

To prevent the casings separating during drawing, the joints were thoroughly "picked" or center-punched as each joint was added to that already in the ground. The joint between the starter and the bottom of the casing was not center-punched so that, in drawing, the casing separated at this point, leaving the starter and drive-shoe in the ground. The casing was used from two to four times before it was discarded. The strainers were elevated and dropped into place by means of the drill rig derrick.

Following closely upon the drilling of the wells came the excavation of the open trench connecting the same, for the reception of the concrete conduit. This trench extended from the surface of the ground to the normal water plane, having a bottom width of 10 ft. with side slopes 1 on 1. The depth of this cut varies from 14 to 19 ft., being almost entirely in a sandy loam formation.

Well Cleaning

Preceding the construction of the concrete conduits and pump houses the wells were thoroughly cleaned. For this work an Ingersoll-Rand compressor of 250 cu. ft. capacity was used. This compressor and its receiver were mounted on a heavy farm wagon and belted to a 25 hp Westinghouse motor placed on the rear end of the platform of the wagon. For discharging the air in the well two different foot pieces or diffusers were used. These consisted of the standard 7-in. foot piece manufactured by the Indiana Air Lift Company, and 7-in. Smith foot piece manufactured by the Pacific Coast Manufacturing Company. Both foot pieces gave satisfactory results.

Air was first admitted to the well under from 10 to 15 lb. pressure and gradually increased at intervals until a pressure of from 35 to 40 lb. per square inch was used. These high pressures were built up in the receiver and wells and forced the air and water far out into the gravels surrounding the wells. Afterwards the discharge valve at the top of the well was opened and the reverse pressure with a consequent inrush of the water into the well carried large quantities of silt, sand and gravel. These intermittent "rammings" with the air were continued until the well ceased to give up sand. While the gravels and sands were generally fairly free from silt and fine material this cleaning process usually caused the well to produce about 50 per cent more water than it would produce before "blowing."

Other material advantages secured in the thorough cleaning of the wells were the elimination of the large amount of sand from the wells, a portion of which would later be withdrawn by the permanent pumps with the consequent wear and loss of efficiency in the latter, and also the prevention of future caves occurring under the conduits and pump houses by the withdrawal of the finer materials before these structures were built.

(To be concluded)

Proposed Test of Sand for Concrete

The testing of tension briquettes or compression blocks of concrete made from wet mortars having the same consistency as used in the work was advocated by Mr. W. B. Reinke, of Philadelphia, in a paper read before the last annual meeting of the American Society for Testing Materials.

The procedure suggested by Mr. Reinke is as follows: The sand to be tested and Ottawa sand are first made into mortars of normal consistency, using preferably cement from the work. These mortars are then made into briquettes, the whole operation being in accordance with the standard methods for the making of sand briquettes when testing cement. The amount of water necessary to make a mortar of normal consistency having been found, a new batch of sand and cement in the desired proportions is thoroughly mixed dry and placed in a cylinder that can be revolved, together with a number of flint pebbles, so that the proportion of cement, sand and stone will approximate that desired in the actual work. To this mix is added enough water (generally about 50 per cent more than needed for normal consistency) to make a mortar having work consistency. The cylinder is then closed and revolved for five minutes. The flint pebbles are picked out by hand and the mortar is made into briquettes. This test, Mr. Reinke pointed out, more closely approximates the conditions found in actual work, and the strengths obtained from briquettes made from such a mortar, though, as a rule, far below those obtained from a mortar of normal consistency, correspond to those that may be reasonably expected from the mortar if the same sand and cement are used in construction.

In most cases, using the same cement, more water will be needed to bring a natural sand to normal consistency than is necessary with Ottawa sand. This difference in the amount of water required is accounted for by the difference in granulometric grading, the work sand, as a rule, having the greater amount of fine material, and hence more surface to be covered and a larger percentage of voids. The more water used, the greater will be the loss in strength at early periods. The nearer a natural sand approaches the ideal in physical and chemical composition, the less will be the loss in strength for each additional per cent of water added.

The amount of water, therefore, required to bring a given sand to work consistency forms one of the best measures of the quality of sand.

In mixtures using 50 per cent more water than required to produce normal consistency, Ottawa sand and good natural sands, Mr. Reinke finds, lose from 25 to 35 per cent of their strength up to the 28-day period, while a poor sand may lose as much as 70 or 80 per cent of the strength developed when made into mortars of normal consistency.

An Ordinance Requiring Weeds to be Cleared from all vacant lots was recently passed in the city of Portland, Ore., and the city engineer was charged with supervision of the work. The first inspection, it is said, reported the location of about 5000 weed patches. The engineer then had posted on all weed-covered lots notices which announced that the owner must clear the land in five days or the work would be done by the city and the cost added to tax assessment. About 10 per cent of the weed-covered area was left for the city to clear.

Public Works in the Philippine Islands Under the American Régime—Part II

Irrigation Works, Artesian Wells, River and Harbor Improvement and Railroads

By H. F. Cameron, M. Am. Soc. C. E., Division Engineer,
Bureau of Public Works of the Philippine Islands, Manila

The irrigation work in the Philippine Islands before the American occupation seemed to be entirely in the hands of the Catholic Church, which practically owned all the best estates on the islands. These estates eventually were acquired by the American Government by purchase and were transferred to the Bureau of Lands for administration, where they are classed as "friar" lands. Where irrigation was at all possible the Catholic Church had extensive systems in successful operation. Some of the tunnels are extremely long, and in their excavation three to four times the necessary rock was handled to make the headings meet. It was the custom of those days for the Church to contract this work to Chinese, who were paid only upon the delivery of water where specified. Where the headings were supposed to meet there may be found large excavated chambers, entries in every direction, rises and shafts, until finally a connection was made between the headings.

Natives Drawing Water at an Artesian Well

These systems have in most cases been repaired and reconstructed so that they are in operation to-day. The Bureau of Public Works has been very much handicapped in this work, because no adequate or reliable hydrographic data could be obtained and because there were no laws under which they could operate had they had the data.

The work of the last five years has been confined to securing data with reference to irrigable areas, flows of streams, the investigations of apparently feasible projects, river control and some minor works of construction, repair and maintenance. Only two projects worthy of mention have been started—the San Miguel project, Tarlac Province, Luzon Island, to irrigate 4,000 hectares, at a cost of $500,000, and the Santa Barbara project, Iloilo Province, Panay Island, to irrigate 3,000 hectares, at a cost of $400,000.

Rice Irrigation

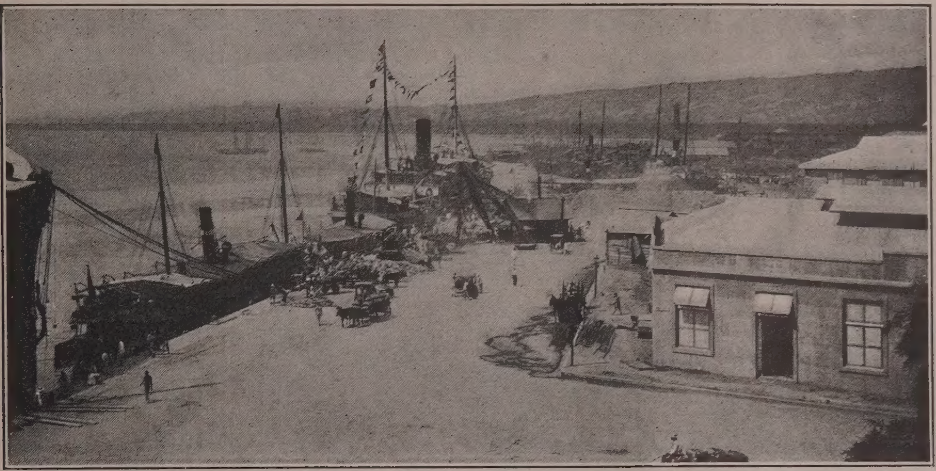
The principal food crop of the Filipino people is rice. The land under rice cultivation approximates 1,000,000 hectares, of which less than 5 per cent. is irrigated. One crop a year is possible without irrigation, but with irrigation two can be secured. The yearly requirements for food of the population of 8,000,000 approximates 1,000,000 tons of rice, while the average crop is about 635,000 tons. Accordingly, the remainder is imported annually from Java, Saigon and China or the people go hungry. The yearly imports of rice for the last fifteen years have averaged about 215,000 tons.

The Island of Java, a Dutch possession, having the same soil and climatic conditions, with a population three times as large as the Philippines, but with an area of only one-half, raises sufficient rice for its own population and exports besides. This is due to the excellent irrigation systems which the Dutch Government has installed throughout the island.

The Filipino people are now awake to the rice situation, and the next decade promises to change the Philippines from an importing to an exporting country. The Bureau of Public Works has been untiring in its efforts to remedy the irrigation situation, and the thorough law which it presented to the Legislature was passed by that body on Feb. 6, 1912. This law provides a system for the appropriation of public waters and the determination of existing rights thereto; for the public registration of all water rights; for the creation and use of water power; for investigation, construction, maintenance and operation of irrigation systems by the government; for the repayment of money expended therefor; for the construction, maintenance and operation of irrigation systems by private persons; for the inspection of all works pertaining to the use of water and penalties for its violation. The application of this law will do much in the years to come for the furthering of the agricultural development of the islands.

Artesian-Well-Water Supplies

Probably the most popular work carried on by the American Government in the Philippines is that of the artesian well division of the Bureau of Public Works, as the results of it are immediately and directly apparent to the people. The Spanish Government gave little thought to water supplies or other sanitary work in the Philippines. A gift of General Antonio Carriedo in 1748 for a water supply in Manila did not bear fruit until 1878, when



Port of Cebu Showing Reclaimed Land and Sea-Wall

the construction work on the old Manila water system began. For 400 years the main source of supply for the Filipino people has been derived from surface wells. As the people have always lived as closely together as possible for protection, as there are no facilities for the disposal of fecal matter of man or beast, as cholera, typhoid fever, enteritis, diarrhœa and dysentery are common Philippine diseases which are transmissible by water, and as about all of these diseases are caused through pollution as indicated by the presence of the Colon bacillus, it is very easy to account for the terrible mortality that has taken place in China, India and the Philippines in the past. Due to the excellent work being done by the Bureau of Health in the Philippines and the development of artesian and other pure-water supplies by the Bureau of Public Works, these epidemics can never reach the proportions of the past.

The government is now operating thirty deep-well rigs and fifty jet rigs all over the islands, and at the end of June, 1912, had eighty successful deep wells of the one hundred and eleven drilled and four hundred and sixty-six successful wells with jet rigs of the five hundred and seventy-five drilled. To-day there are probably more than seven hundred successful artesian wells distributed over the islands. The government has adopted a broad attitude toward this sanitary work by giving an allotment of insular funds equal to twice that deposited by a municipality toward drilling a well. Besides the artesian well work many gravity supplies of impounded water or spring water have been constructed in localities where artesian wells have been unsuccessful. Of the former class the systems of Manila and Cebu are the only examples.

MANILA'S NEW WATERWORKS

The early Manila waterworks system was a pumping plant situated about 10 kilometers from Manila on the Mariquina River and pumping into an underground reservoir, whence it flowed by gravity into the city. This system was designed and executed by the Spanish Government. On account of the inability to supply the present population of Manila with water a new system was designed and constructed in 1909 by the American administration. The salient features of the new supply were the damming of the Montalban River, which drains a watershed reservation of 27,980 hectares, at a point 35 kilometers from Manila; conducting the water by tunnel and 42-in. steel pipe line to the new 54,500,000-gal. reservoir excavated in rock, and a 42-in. pipe line to the Manila distribution system, where a pressure of about 40 lb. per square inch is obtained. The dam was of the curved overflow gravity type, constructed of cyclopean masonry with squared-stone face. The base width was 20 meters; the height, 17 meters; the crest length, 58 meters, and the radius of curvature, 96.3 meters. The chief engineer of this system was Major J. H. Case, who for ten years was connected with many of the civic improvements of Manila as a government engineer.

The Osmena waterworks system of Cebu, P. I., was similar in general features to the Manila system. Due to more favorable location of reservoir and distribution tank, with the addition of an exceptionally desirable dam site, the system was easier and much less expensive to construct. The main feature of this project was the design and construction of the dam. The site was a narrow rock gorge 5 meters wide at the base and 40 meters at the crest of the dam. The bottom and sides of the gorge were of a mineralized andesite flow, none too dense and somewhat shattered in the upper courses. A reinforced-concrete arch dam, 30 meters in height, was the type decided upon for this location, designed for a maximum compressive stress of 250 lb. per square inch for plain concrete.

To illustrate the unusual weather conditions encountered in the Philippines, it is sufficient to know that the records from the Cebu Weather Observatory for Cebu gave a maximum record of 2 in. of rainfall for two consecutive hours and 5 in. as the maximum daily rainfall. The spillway of the Cebu dam was designed for 3 in. of rainfall an hour for two consecutive hours, and an additional parapet wall was constructed to give additional storage to meet worse conditions. A month or so after the completion of the dam, during the October, 1912, typhoon, which caused so many deaths from floods in the Philippines, there was a 4-in. fall of rain which filled the main reservoir to spillway elevation and completely saturated the watershed area. During the same night the rain came down in torrents, with a record of 22 in. This, of course, was more than the spillway could discharge. Consequently the water passed over the crest of the dam, and finally over the parapet wall, giving a head on the spillway of 1.75 meters. The spillway as designed provided for a head of 1.2 x 20 meters in length, while the maximum discharge had a head of 0.6 meters for a 70-meter spillway length.

This gave the dam design and construction a more severe test than was intended, at a time when the structure had not attained its full strength, but no failure of any sort occurred to the dam, though one flank was weakened considerably by a failure in the natural rock foundation, which was undermined by the water flowing over the parapet wall.

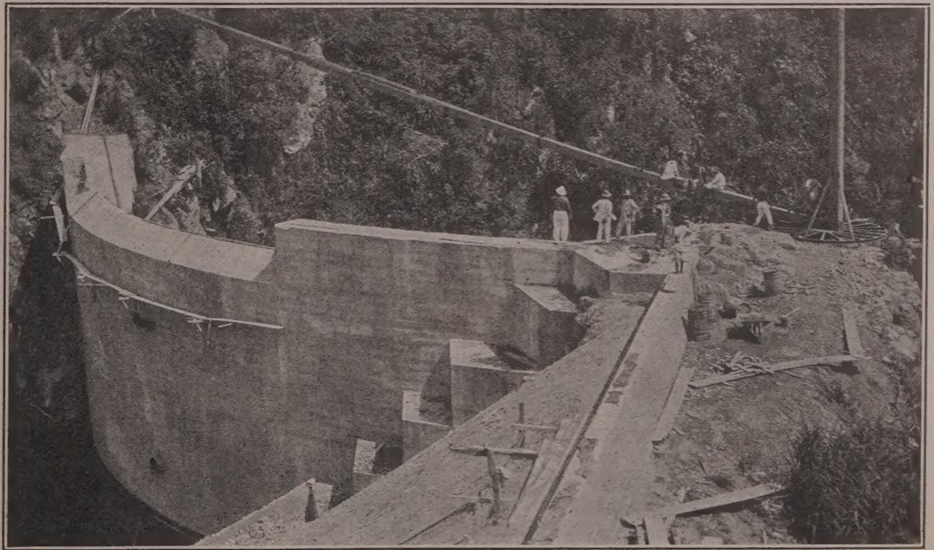
HARBORS

The administration of the port works in the Philippines has been varied. Originally the Bureau of Public Works executed this work, then it passed into the hands of the U. S. Army engineers, and finally to the Bureau of Navigation.

Under the early administration no work was done outside of Manila, except lighthouse construction. In Manila, however, great energy was shown in carrying out the plans left by the Spanish engineers for extending the breakwater and so forming an inside basin that permits vessels to anchor in safety at all seasons of the year. This basin has been dredged to a depth of 10.5 meters and the material used for making a new business area known as Reclamation No. 1, which has provided more than 600,000 sq. meters of new space for warehouse construction. As an integral part of this reclamation there have been constructed three large wharves and sheds, which are equipped with modern freight-handling machinery.

The Pasig River has been dredged to a 5.5-meter depth to the Bridge of Spain to accommodate the majority of the inter-island steamers. In addition about 8 kilometers of the esteros (canals) in Manila have been dredged to allow the loaded cascos to navigate at mean tide.

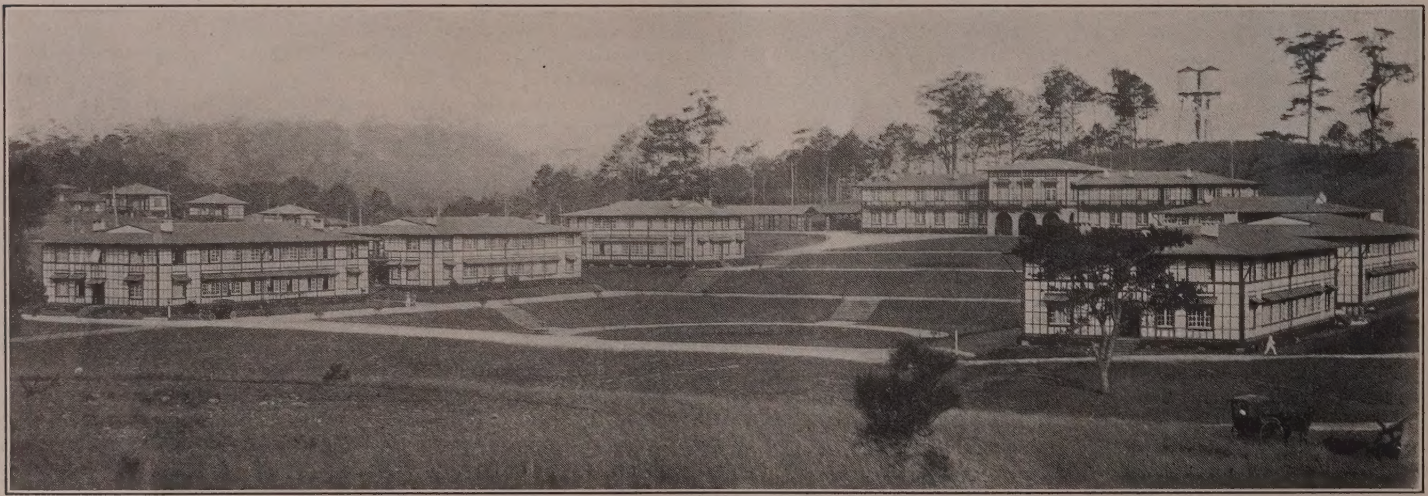
At Iloilo, Panay Island, the Iloilo River has



The Curved Concrete Dam for the Cebu Waterworks been dredged to a 5-meter depth, large reclamations made for business purposes, and 400 lin. meters of reinforced-concrete wharf constructed on the south side of the river to facilitate cargo handling. Iloilo is the chief exporting city for Philippine sugar.

At Cebu, Cebu Island, a monolithic concrete sea wall, 700 meters in length, has been constructed to accommodate vessels drawing 5.5 meters of water for one section and 7 meters at another. A reinforced-concrete section, 250 meters in length, is now in course of construction to accommodate vessels drawing 9 meters of water. A large area reclaimed from this harbor is now covered with reinforced-concrete warehouses. Cebu is the principal port for the exportation of Manila hemp.

There are a great many smaller harbor projects in course of completion that will aid much in the commerce of these islands. Under Spanish régime practically all the export and import cargoes were handled in the harbors by small lighters, while to-day this rehandling has been eliminated in the large ports of the islands.



Offices and Dormitories of Insular Government Staff at Baguio, the Summer Capital of the Philippines

The only railroad line in existence previous to American occupation was an English system, known as the Manila-Dagupan Railway, that extended north from Manila through the large and fertile central valley of Luzon Island for a distance of 170 kilometers. The gauge of this line was 3 ft. 6 in., the rails weighed approximately 45 lb., the ballast was of extremely fine river gravel or sand, and the bridges were of wood. The rolling stock consisted of small locomotives of about 20 tons capacity, that handled freight and passenger cars of a size that suggested children's playthings. The size of the passenger cars depended upon their use—whether for first, second or third-class passengers. As the bulk of the passengers carried was third class, the policy of the company evidently was to make the first and second-class passengers as uncomfortable as possible to discourage this class of travel. It catered especially to the profit-making third-class passenger and freight traffic. The comfort in traveling, eliminating the crowding and odors in the third-class carriage, was in inverse ratio to the fare paid.

This same rolling stock may be seen in Manila to-day on some of the new lines that have not yet attained a paying basis.

The American Government in the Philippines, however, in order to throw open for settlement the larger tracts of fertile, idle lands in the interior so as to fully develop the vast resources of these islands, has given a great impetus to railroad construction by guaranteeing a 4 per cent interest on approved construction costs for a fixed number of years, thirty in some cases.

Up to June 30, 1912, there were 621 miles of railroad in operation, of which 563 miles belonged to the two companies that are constructing under government guarantee—the Manila Railroad Company, of which the old Manila-Dagupan is a part, and the Philippine Railway Company.

All roads are of 3-ft. 6-in. gauge, except the Manila electric railway, which has adopted the American standard gauge.

Steam Railroads

The Manila Railroad Company is divided into two companies—one is the English company, with headquarters in London, and the other the American company, with headquarters in New York. The company works on the Island of Luzon and is constructing two main trunk lines, one running north from Manila, with the old Manila-Dagupan as a starter, and the other south of Manila.

The trunk line north of Manila to Dagupan with its feeders serves a rice and citrous country that will guarantee tremendous returns on the investment. From Dagupan north, however, it is a coastal road that must compete with water transportation. One feeder from this section that is now under construction will convey passengers and freight to Baguio, the Philippine summer capital in the mountains, which is not unlike Simla in India.

The trunk line south has an approximate length of 84 miles to Lucena, Tayabas Province, which, with its feeders, totals about 170 miles of line in operation, giving an outlet to a large cocoanut, coffee, corn, hemp and orange country. On these southern lines up to June 30, 1912, the total authorized bond issue on guaranteed lines was $4,936,000 covering 142.3 miles of line, all in full commercial operation. The average cost per mile on these southern lines was $34,688.

Interest amounting to $222,371.11 had been paid out on these guaranteed bonds up to June 30, 1912; of this amount all except $16,865.12 had been returned to the government from net earnings, with $7,135.07 to be returned for the previous year.

The new rolling stock on these lines is constantly being improved, but the first-class coaches of the compartment type, continental in character, leave a lot to be desired for comfortable traveling in a tropical country. The southern China lines and the English lines in Cuba are very much superior in this respect.

The Philippine Railway originally undertook construction of lines on the Islands of Cebu, Panay and Negros on government guarantee. The lines on Cebu and Panay Islands have been in operation for several years, but no construction work has been done on Negros Island.

On Panay Island the trunk line extends north and south through a large fertile interior valley, similar to the Luzon northern line described in the foregoing paragraphs. This valley differs from the Luzon valley in that it is very sparsely settled. The line eventually should prove very profitable for its owners. The southern terminal is Iloilo, which has good shipping facilities and now exports practically all the sugar of Panay and Negros Islands, while the northern terminal is Capiz, that offers some possibilities for harbor improvements which, if ever constructed, will shorten the distance to Manila very materially.

This line is 71 miles in length, and up to June 30, 1912, the total amount of bonds authorized for construction on Panay Island was $5,065,000, which gave a construction cost of $70,005 per mile.

Cebu Island, however, differs topographically from Luzon or Panay inasmuch as there is no large interior valley. The island is long and narrow, with a ridge the whole length of its center ranging from sea level to 800 meters in elevation. The railroad line, therefore, is coastal, extending 19 miles north of the Port of Cebu and 38 miles south. Cebu Island is the most densely populated of the Philippines, and its area is probably more extensively cultivated than any other island, but the individual holdings are small and the soil is poor. On account of the dryness of this island corn is the staple crop, from two to three crops a year being possible.

Up to June 30, 1912, the government had approved a total bond issue of $3,317,000 for the Cebu line, which gave a construction cost of $55,842 per mile.

The government, up to July 1, 1912, had paid out in interest on guaranteed bonds to the Philippine Railway Company, excluding cost of exchange, a total of $1,120,914.12, of which there was returnable from net earnings $52,882.50, leaving a balance due the government of $1,073,322.59.

The station agents, conductors, brakemen, locomotive engineers and firemen are almost all Filipinos, supervised either by an American or European on all these lines. On the Luzon lines the native Tagalog is found, while on the southern-island systems the Visayan. While the former has had the advantages of longer experience with construction work and mechanical appliances, and to-day is probably the more dependable, the Visayans are rapidly forging to the front along all lines and eventually will probably outclass the Tagalogs.

The Manila Electric Railroad & Light Company, in conjunction with the Manila Suburban Railways Company, operates 43 miles of electric railway. For the calendar year 1911 the operation of the electric railway for the former company showed an operating revenue of $1,310,850, an operating expense of $625,628 and an operating income of $319,351. The percentage of operating expenses to gross revenue was 48 and total pay passengers carried were 14,656,254 for a mileage of 40. During the same time the Manila Suburban Railways Company, with 7 miles, had an operating revenue of $157,702, an operating expense of $67,730 and an operating income of $77,491. The percentage of operating expenses to gross revenue for this line was 41, and 3,995,621 pay passengers were carried.

The U. S. Coast and Geodetic Survey, in conjunction with the American Government in the Philippines, has five steamers in the field continuously on triangulation, topography, hydrography and magnetic survey work. The Bureau of Lands had up to June 30, 1912, surveyed 7,400 statute miles of the 11,500 miles of general coast line in the Philippines, had run 172,876 statute miles of soundings, and 66,217 square statute miles of hydrography survey.

The Philippine Islands are far away from the United States and interest the average citizen but little. It should be known, however, that the American Government during its fifteen years' possession of the Philippine Islands has accomplished more to develop the resources of this country by means of good harbors, lighthouses, roads, bridges and railroads than the Spanish Government did in four hundred years of possession.

The organization of the Bureau of Public Works is as follows: Mr. Warwick Greene, director; Mr. C. Lindsey, assistant to the director; Mr. E. J. Westerhouse, chief division engineer; and Mr. D. E. Henry, Mr. E. P. Shuman, Mr. W. H. Waugh, Mr. B. von Schmeling and the writer, division engineers.

Rice Paddies on the Mountain Sides of Luzon, P. I.

This development is the work of the uncivilized Igorrote.

Economy of Motor Trucks in Paving Work

Motor trucks have been used successfully in the hauling of material, supplies and equipment by the Warren Brothers Company, paving contractors, of Boston. Two 5-ton White trucks and one of 1½ tons capacity have been in use less than a year, and in that time they have replaced ten of the twelve horses formerly maintained in the Cambridge yards and have effected a reduction in haulage costs estimated at one-third. The company believes that it can lower these costs still further by making some changes in its yard facilities to meet the new conditions of transporting and loading. A considerable part of its wagon equipment has already been adapted, with satisfactory results, for use as trailers.

Motor Truck Unloading Hot Paving Material in Street

The company maintains two asphalt refineries in California, the asphalt being shipped by rail and unloaded from a spur track. Crushed stone also arrives in railroad cars and is handled by an inclined cable railroad. Cement is delivered either by rail or by steamship, while gravel reaches the yard in barges from Long Island and is stored in elevated bins and discharged by gravity. Many contracts call for work in cities and towns quite distant from the Boston plant, and in such cases the necessary equipment and tools are shipped and transportation units are hired. The Boston installation is permanent, however, and the facilities have been developed to meet the requirements of street paving, and of sidewalk, building, flooring and roofing work in Boston and vicinity.

When horses were used exclusively the operations of the company were limited to a circle of 10 miles radius with Boston as its center. This limiting distance is due to the fact that the bitulithic surfacing material, composed of crushed stone, gravel and fluid asphalt mixed at a temperature of 300 deg., must be loaded, hauled and dumped before it cools. The work can be done only in dry weather. The mixture must be delivered at practically the same consistency as when discharged from the mixer. There must also be enough men at work on the paving job to handle the surfacing when the material arrives.

Careful figures compiled by the company covering both horse and motor-truck installations show that each of the large trucks did the work of three and sometimes four teams. When trailers were used each train supplanted five or six teams. The use of trucks also extended the area within which paving contracts could be made, and one contract in Haverhill, 38 miles distant, was carried out, the trucks and trailers being used to carry not only material but also tools, portable furnaces and other equipment, thereby saving time and freight charges.

Two of the trucks have dump bodies of special design, built of sheet steel, which are elevated by the standard White power-dumping mechanism, which allows an angle of 45 deg. The bodies are 11 ft. long, 6 ft. wide and 18 in. deep, with a capacity of 100 cu. ft. The paving material weighs about 100 lb. per cubic foot, making the weight of a full load about 5 tons. The 1½-ton truck has a regular stake platform body.

Oiling State Roads in Maryland is accomplished by the state Good Roads Commission with a 40-hp auto truck of the worm gear type carrying a tank holding oil sufficient for one mile of road, spreading at the rate of ½ gal. per yard.

Report on Weir in the Niagara River

Investigations as to Advisability of a Dam at the Outlet of Lake Erie, or of "Compensating" Works Without Complete Regulation

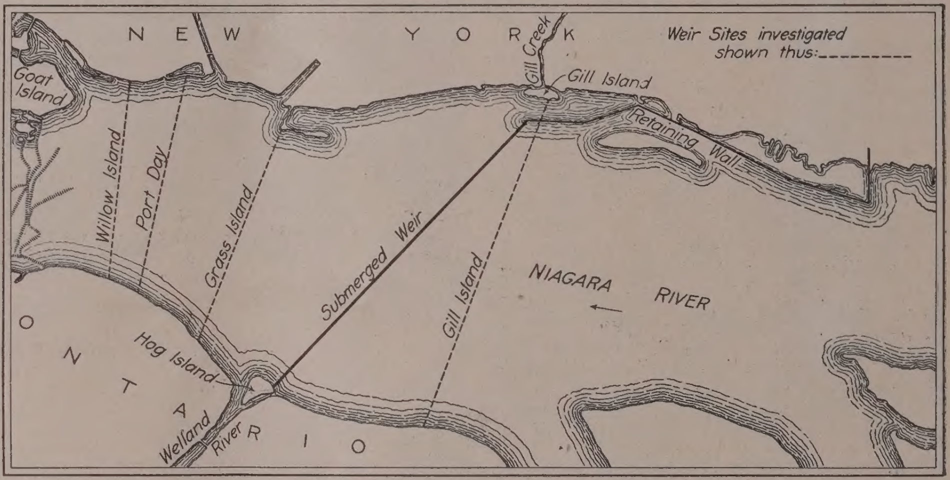
In the act of Congress which resulted in the formation of the International Waterways Commission it was stipulated that one of the duties of the commission should be to report on the advisability of locating a dam at the outlet of Lake Erie, with a view to determining whether such a dam would benefit navigation. The commission divided its work into two parts: First, as to the advisability of "regulating" works, to reduce the oscillation of the lake, raising the low-water level but not the high-water level; and, second, as to the advisability of "compensating" works, for raising the level at low as well as high water—without complete regulation.

The first part of the problem was reported on by the commission January 8, 1910. The conclusions may be summarized as follows:

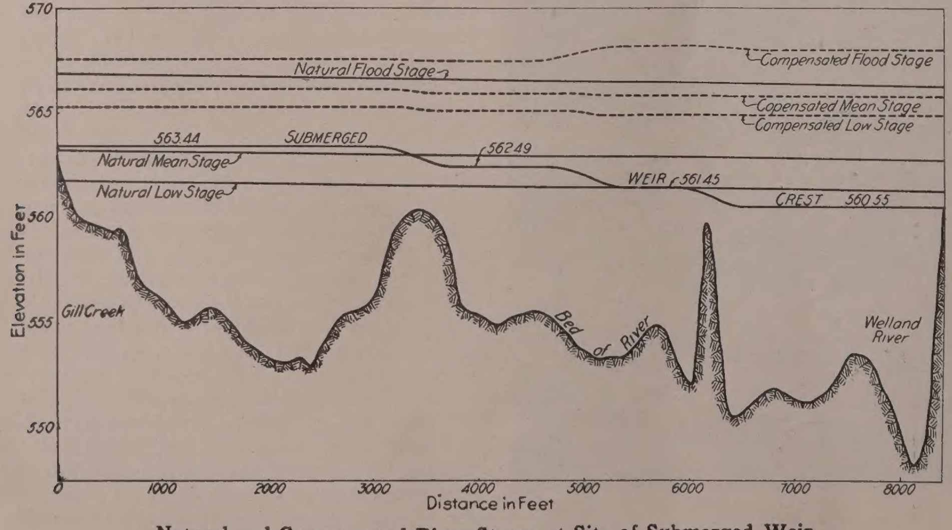
The commission found that only a very moderate degree of improvement in regulation over what nature provides is practicable in any of the lakes, and that, such as it is, this improvement would be obtained at the expense and to the injury of the channels below. In the case of Lake Erie it would be possible to raise the extreme low-water stage about 1 ft., and this in turn would raise the low-water stages of Lake St. Clair about 0.61 ft. and of Lake-Huron-Michigan about 0.27 ft., all without appreciable increase in the extreme high stages. But in doing this the low-water stage of Lake Ontario would be lowered about 4½ in., the available dept in the St. Lawrence Canals would be diminished about 7 2/3 in., and the city of Buffalo would suffer by increased damage from floods and by a postponement of the date of opening navigation in the spring. The question of damage to vested rights was thus introduced. While the advantages of regulation might outweigh the disadvantages if the persons who were to benefit from the former were identical with those who were to suffer from the latter, the difference was not great enough to justify the two governments in entering upon the vexatious question of damages. The commission therefore recommended that the regulation of Lake Erie be not undertaken, meaning thereby the most complete practicable regulation such as can be secured by a dam and sluice gates located at or near Buffalo.

The second branch of the subject, works to raise the level of Lake Erie with partial but not complete regulation, called by the commission "compensating" works, is the subject of a report dated June 20, 1913, from which the following extracts are taken:

From a study of the maps it appears that the best site for a submerged dam, or weir, is just above the Welland River, extending from Hog Island, at the mouth of that river, to the mouth of Gill Creek, on the American side, as shown in one of the drawings. As the Welland is a navigable stream, there would be some advantage in placing the weir below its mouth, but the survey of that river showed that a moderate increase in the height of its surface would submerge a considerable area of valuable land. To provide for the navigation of the Welland it is necessary to construct a lock at the Canadian end of the weir. The object of placing the weir as near as possible to the foot of navigation is to improve all of the navigable portion of theNiagara River above. A study of the topography on both sides of the Niagara River showed that the water surface at mean stage could be raised as much as 3 ft. at the site of the weir without inflicting damage upon adjacent lands, except for a distance of about 1½ miles immediately above the weir on the American side. At this place it is proposed to construct a levee of suitable height to protect the land from overflow.



Map Indicating Location of Submerged Weir and Sites Investigated



Natural and Compensated River Stages at Site of Submerged Weir

The form to be given the weir has been the subject of careful investigation. In order to disturb as little as practicable the natural distribution of flow through the different parts of the cross-section of the river, the crest of the weir is broken into four sections, as shown in one of the drawings, the height given to each section being such as will raise the surface of the water in that section 3 ft. at mean stage.

FORM OF WEIR

A cross-section of the weir is also shown. This form was adopted after experiment with various types of weir made under as nearly as possible true river conditions. The type of weir desired is one which shall be very efficient at high stages of the river, and much less so at low stages. The form adopted fulfills the conditions, though it is quite possible that a still better form may be developed with further experiment.

The weir would raise the level of Lake Erie 0.51 ft. at extreme low stage, 0.39 ft. at mean stage, and 0.11 ft. at extreme flood stage. At low water the surface of the Niagara River would be raised 1.08 ft. at the Buffalo waterworks.

The effect of raising the mean level of Lake Erie 0.39 ft. would be to raise the mean level of Lake St. Clair about 0.23 ft., and the mean level of Lake Huron about 0.09 ft.

To change the level of a great inland sea like Lake Erie, upon the shores of which are many populous cities, is a matter to be approached with caution. Any important increase in the height of the high-water level may cause serious damage to the wharves and low-lying lands. Care must be taken to avoid injury to vested rights. In this case, the ordinary high-water level is increased only 0.38 ft., or 4½ in., and the extreme flood stage at Buffalo is increased only 0.11 ft., or 1 1/3 in.

The construction of the weir recommended in this report will affect to some extent the levels in the first reach of the Barge Canal from Tonawanda to Lockport. The level of the Niagara River at Tonawanda would be raised by 1.71 ft. at mean stage, and by 0.55 ft. at flood stage, so that inasmuch as no provision has been made at the entrance of the canal against the rise which the construction of the weir will cause, it is in the commission's opinion necessary to provide for the construction of a guard lock, the cost of which is included in the general estimate.

The capacity of the lock to enter the Welland River is a domestic question to be decided by the Canadian Government. An item of $500,000 in the estimates provides for the construction of that lock, but its dimensions should conform to the capacity which the Canadian Government shall determine to give to the connecting waterways, and this estimate can be regarded at best as only a rough approximation.

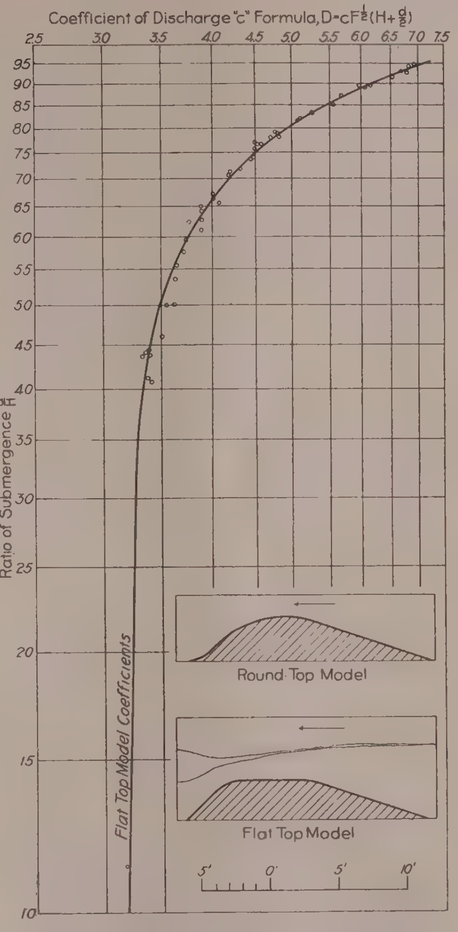
The weir is to be constructed of concrete and its cost is estimated as follows:

Rock excavation, 36,300 cu. yd., at $4	$145,200
Concrete, superstructure, 44,000 cu. yd., at $12.	528,000
Concrete, substructure, 48,500 cu. yd., at $10	485,000
Cofferdam, 105,500 cu. yd., at $3.50	369,250
Pumping and maintenance, lump sum	210,000
Lock into Welland River	500,000
Guard lock at Tonawanda	500,000
Excavation for retaining walls along Niagara River, 16,000 cu. yd., at $3	48,000
Concrete for retaining walls, 12,500 cu. yd., at $10	125,000
	2,910,450
Add for engineering and contingencies about 20 per cent	589,550
Total	3,500,000

The great value to the navigation interest of an increase of 6 in. in the low-water depth of Lake Erie has already been pointed out. (Earlier in the report it is shown that the traffic in the Detroit River in 1910 was 73,526,602 tons, and that in the larger vessels 85 additional tons can be carried for each inch of additional depth.) The improvement of the Niagara River to be effected by the proposed weir is important. An incidental advantage in its construction is that it would eliminate the possibility of power companies at the Falls having any injurious effect upon the level of Lake Erie. The Niagara River below the weir and the conditions upon Lake Ontario and the St. Lawrence River would remain without appreciable change. The weir has small regulating effect upon the levels of Lake Erie, the range of the oscillations of the lake being reduced about 4½ per cent. The average natural low stage, 571.3, is raised 0.45 ft., and the average natural high stage is raised 0.38 ft., a difference of 0.07 ft. The storage in Lake Erie is reduced only by that amount, which is not sufficient to affect the level of Lake Ontario seriously.

It is possible that the Canadian Government may prefer to assume the damages from overflow in the valley of the Welland River, which would be caused by placing the Canadian end of the proposed weir below the mouth of the Welland, and thus make the lock unnecessary. If so, provision for this should be made in any treaty.

The commission believes that the very great advantages to navigation interests will justify and amply repay the necessary expenditure, and recommends that a treaty be entered into between Great Britain and the United States for the construction of the weir.



Experimental Coefficients of Weir

Appended to the report are the findings of the committee of engineers, Messrs. E. E. Haskell for the American section of the commission, and Mr. W. J. Stewart for the Canadian section, which studied the engineering problems. The following extracts give the most important points brought out.

Best Type of Weir

In order to determine the best type of weir, it was deemed necessary to study various types under as nearly as possible true river conditions. These studies were made at the hydraulic laboratory of the college of civil engineering of Cornell University, the use of which was generously offered for this purpose. They covered experiments on seven different types, ranging in height from 3.7 to 6.02 ft. and having in general a 3 to 1 upstream slope and a 1 to 1 downstream, five having a flat crest and the remainder a rounded crest. In two of the flat-top types, the upstream, and in all the downstream corners were rounded on a radius of 9.5 ft. On two of the flat-top and all of the round-top types, the downstream nappe was an ogee curve. These experiments furnish what was being sought, namely, a type of submerged weir that would be very efficient at high stages and much less so at low stages.

Fortified with these new data, a study was made of the probable effect of submerged weirs placed at right angles to the general direction of the river in the following localities: Willow Island, Port Day, Grass Island and Gill Island, as well as one on a line between Gill Creek and Hog Island, at the mouth of Welland River. Only the last of these met the conditions desired.

Diversion of Water from Lakes

As shown in the previous report of the commission, Jan. 8, 1910, the stage of water in several of the Great Lakes will be materially lowered by artificial diversions of water therefrom. This loss of level on Lake Michigan-Huron, if 10,000 sec. ft. be taken through the Chicago Drainage Canal, will for mean stage amount to 0.53 ft., while the loss of level to Lake Erie due to this diversion and 1000 sec.-ft. through the Erie Canal and 1100 sec.-ft. through the Welland Canal will at mean stage amount to 0.43 ft. and 0.09 ft., respectively, a total of 0.52 ft. The American power companies have also lowered the level of Lake Erie probably by 0.08 ft.

The project here proposed for restoring the loss caused by these diversions is the construction of a submerged weir of suitable type, on a line between Gill Creek and Welland River, of such a height of crest as will create sufficient backwater to offset it.

To determine this, backwater curves have been computed, based upon Bernoulli's theorum for steady flow. The backwater on Lake Erie caused by the submerged weir has also been computed by the supply, storage and discharge method.

Owing to the fact that the weir has an increasing efficiency with increase in stage, it was thought that the flow of the river might vary slightly from present natural conditions and therefore might affect injuriously the stage of water in the St. Lawrence Canals. The computed results show that the effect on Lake Ontario of any variation in the flow from

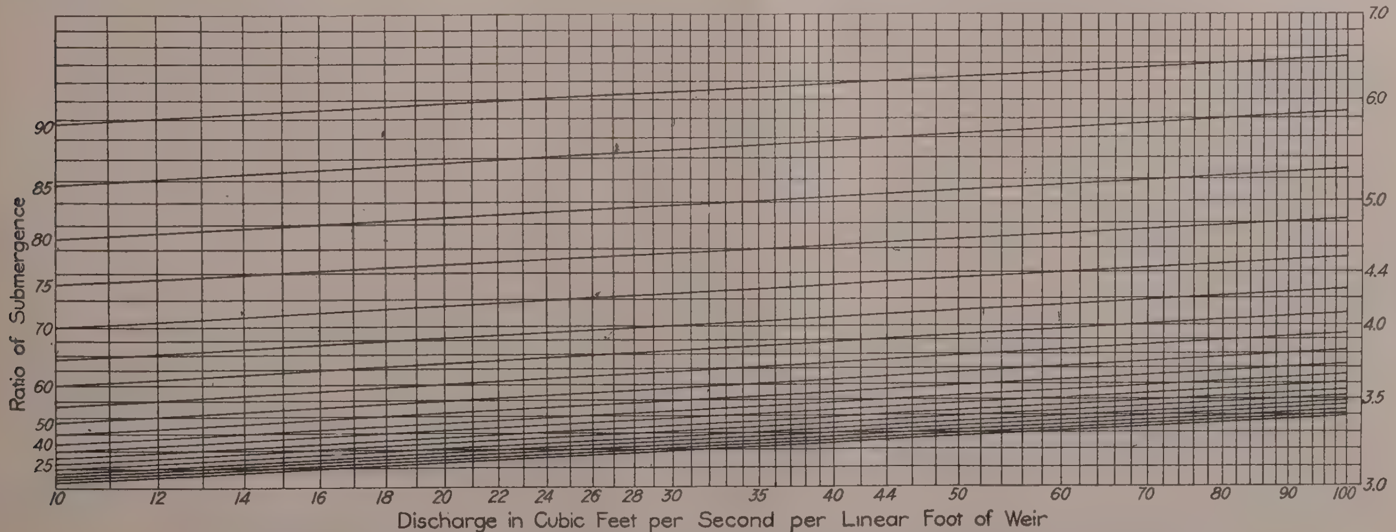


Diagram of Submerged-Weir Coefficients Based Upon Experiments Made at Cornell University

Table 1—Dimensions of Submerged-weir Models

Model No.	Length feet	Height feet	Crest	Bottom width feet	Upstream face	Downstream face	Remarks
1	4.005	6.02	Flat 6 feet wide..........	31.76	1-3 slope	1-1 slope	Upstream corner sharp, downstream corner rounded, radius 9.5 feet.
2	4.01	4.53	Flat, 6 feet wide..........	25.79	1-3 slope	1-1 slope	Do.
3	4.01	4.53	Flat, 6 feet wide..........	27.33	1-3 slope	1-1 slope	Up and down stream corners rounded, radius 9.5 feet.
4	4.02	5.17	Rounded, radius 9.5 feet..	27.70	1-3 slope	1-1 slope	Ogee curve downstream face.
5	4.005	4.35	Rounded, radius 9.5 feet..	23.50	1-3 slope	1-1 slope	Ogee curve bottom, downstream face.
6	4.005	3.70	Flat, 6 feet wide..........	23.50	1-3 slope	1-1 slope	Upstream corner sharp, downstream corner rounded, radius 9.5 feet. Ogee curve bottom downstream face.
7	4.005	3.70	Flat, 6 feet wide..........	25.04	1-3 slope	1-1 slope	Up and down stream corners rounded, radius 9.5 feet. Ogee curve bottom downstream face.

Table 2—Weir Co-efficients, Flat-top Model

Weir condition	Av. min. river flow per lin. ft. of weir sec.-ft.	Coefficient	Av. mean river flow per lin. ft. of weir sec.-ft.	Coefficient	Av. max. river flow per lin. ft. of weir sec.-ft.	Coefficient
Free	18.00	3.120	25.00	3.160	45.00	3.260
0.1 submergence	18.00	3.145	25.00	3.190	45.00	3.300
0.2 submergence	18.00	3.195	25.00	3.245	45.00	3.345
0.3 submergence	18.00	3.260	25.00	3.308	45.00	3.419
0.4 submergence	18.00	3.340	25.00	3.397	45.00	3.500
0.5 submergence	18.00	3.480	25.00	3.540	45.00	3.655
0.6 submergence	18.00	3.720	25.00	3.780	45.00	3.900
0.7 submergence	18.00	4.125	25.00	4.190	45.00	4.320
0.8 submergence	18.00	4.850	25.00	4.910	45.00	5.060
0.9 submergence	18.00	5.930	25.00	8.025	45.00	6.210

Lake Erie caused by the submerged weir would be negligible.

So far as can be seen, but little, if any damage would result from the proposed weir placed on the Gill Creek-Welland River section.. It would not be possible to raise the water at the weir by much more than 3 ft. without danger of damage from floods.

Submerged-Weir Experiments

All of the weir models were approximately 4 ft. long. Table 1 gives the dimensions of the several models tested.

These models were placed in a wooden flume 95.5 ft. long, 10 ft. high, and 4 ft. wide, constructed in an open concrete canal. The dimensions of the canal are 418 ft. long, 16 ft. wide and 10 ft. deep. The grade of bottom of channel is approximately 1 ft. in 500. A bulkhead located about 60 ft. from upper end of canal divides it into two parts. A standard sharp-crested weir placed on top of this bulkhead measures the quantity of water flowing in canal. The wooden flume mentioned above was built in this canal, the upper end being located about 87 ft. below the standard weir. The upper end of flume had a bell-shaped mouth, about 15 ft. long, converging from 16 ft., the width of canal, to 4 ft., the width of flume. The crest of weir of tested models was placed about 46 ft. below upper entrance to bell mouth. The flow of water over the standard weir, through the canal, and over the experimental models was regulated by gates at the head and foot of canal. By the manipulation of these gates various discharges, submergences and heads on the experimental weir models were secured. The upstream head was measured in the flume with a plumb-bob attached to a steel tape at a point about 25.5 ft. above the upstream edge of crest of flat weir, while the downstream head was measured in the same way in still water behind the flume on both sides and about 16.6 ft. downstream from the upstream edge of crest of flat weir. The longitudinal water-surface curve over the weir was determined for all models under various conditions of flow. The flow of water over these experimental models varied between 27.6 and 203.2 sec.-ft., equivalent to 6.87 and 50.75 sec.-ft. per linear foot of weir, respectively. The upstream heads on the weir varied between 1.66 and 6.35 ft. and the ratio of submergences between 0 and 95. The experimental coefficients as derived are based upon the formula $D = cF^{\frac{1}{2}} (H + d/2)$ for submerged weirs, where D=discharge per linear foot of crest, H=upstream head, d=downstream head, F=fall or upstream head minus downstream head, c=experimental coefficient. The weir coefficients for the flat-crest models are given in Table 2 and are shown in the accompanying illustration.

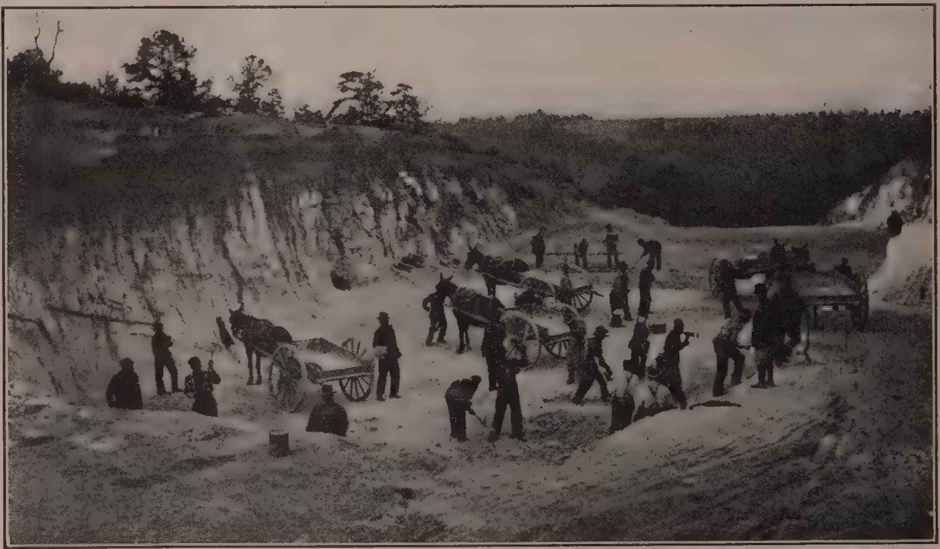
The weir coefficients of the round-crest models were about 5 per cent greater than those of flat-crest models, but the coefficient increment was about the same for each type within the limits for river conditions. The flat-crested model was therefore adopted on account of the easier construction, inspection and repair.

The committee does not wish it understood that the type of weir here proposed is the most desirable one for the purpose. The experiments made were by no means sufficient to settle this question. It is very probable that further experiments would reveal a still better type. The one proposed does demonstrate, however, the committee believes, that the project is feasible.

Converting Pine Mountain Tunnel Into an Open Cut

Pine Mountain tunnel, on the single-track line of the Southern Railway between Atlanta and Columbus, Ga., has recently been converted into an open cut. The tunnel, which was cut through rock, was about 500 ft. long, the maximum depth above its top being about 57 ft. The material was mostly rock and the general procedure was to begin at the top, set off light blasts, haul the loose material in mule carts to the ends of the tunnel, and drop it down through openings in heavy plank platforms into dump cars on the track. The spoil was used to fill nearby trestles. About 32,000 cu. yd. were involved, the material filling three large trestles.

Near the middle of the tunnel a cave was encountered before the excavation had progressed very far. Its extent was unknown and a shaft was sunk through it to the tunnel. A hole, 25 x 28 ft. in plan, was excavated down to a depth of about 40 ft. below the level already reached in the cut, 200 sticks of dynamite were placed and the timber lining and remaining rock blown out. This blocked the track for several days, during which night and day shifts worked at clearing away the débris. This accomplished, the tunnel was reopened for traffic and the hole closed with a timber floor in which there was a hatch, enabling the shaft, as well as the platforms at the ends of the tunnel, to be used for loading the spoil.



Excavating Pine Mountain Cut, Using Hand Labor and Mule Carts.

The work was carried out under the direction of Mr. R. D. Tobien, engineer maintenance of way.

Buffalo Harbor Improvements have been materially advanced by the installation of a bascule bridge across Buffalo River for the Lake Shore Railroad. The bridge was put in operation on Aug. 5. Capt. George H. Norton, commissioner of public works, is quoted as saying that it was one of the most important moves in the history of the city waterfront in that it admits the plant of the Great Lakes Dredge & Dock Company to a portion of the river heretofore blocked against navigation and will permit the extension of navigation up to the Nickel Plate, Pennsylvania and Buffalo Creek-Erie bridges which will in a few months be replaced by bascule structures and open a mile of additional valuable dockage front along the river banks.

Equipment and Performance of the British Columbia Dredging Fleet

Operating Costs for Five Different Types of Dredges and Auxiliary Plant, with a Discussion of Causes of Delay

The dredging fleet operated in British Columbia waters by the Department of Public Works of Canada at the close of last year included five different types of dredges and a complete auxiliary equipment, the whole having been assembled to meet the unusually diversified conditions to be found in the harbors, rivers and inlets of British Columbia. In the last four years, during which time the fleet has been under the personal supervision of Mr. H. A. Bayfield, a large proportion of the whole equipment has been selected and put in service. The fleet has been increased in accordance with the rapid development of the country so as to provide adequate means for carrying out the harbor improvement work as needed. In most instances where new units were added the type chosen was that deemed best suited for work in a certain locality, as, for example, in the case of the scraper suction dredge Fruhling, which was purchased specially for dredging the sand heads at the mouth of the Fraser River.

These conditions, coupled with the fact that a very complete record has been kept of the operation of all dredges, make it possible to compare capacities and costs for dredges of different types when each is handling the materials for which it was designed and all are working under the same general conditions as to overhead costs, supervision and climate.

The system of weekly reports instituted by Mr. Bayfield for this dredging fleet comprises a set of blank forms applying to each type of machine in use, and calls for detailed but easily obtained information on the performance of each unit. These reports must be signed by certain of the vessel's officers and forwarded to the superintendent of dredges each week, who thus has before him data which enable him to locate at once any weak points in the organization or equipment. For convenience in comparison the operating data and costs have been arranged in tabular form. These should be interpreted in the light of the modifying conditions mentioned in the description of each dredge.

Tables 1, 2 and 3 give respectively a list of the dredging fleet, a record of performance, and cost of operation of various units of the fleet.

When operating under the single-shift plan each week included 52½ working hours. When on double shift, 105 hours are figured in each week. When night shifts were inaugurated, the salaries of captain and chief engineer were increased 15 per cent, and these officers were held responsible for the safety, operation and management of the vessel, although, of course, an entirely different crew, in charge of a mate, was on duty at night. In Table 2 the item "Total Hours on Duty" represents the time during which the vessel was manned by her crew, and "Hours Actually Dredging" is time during which material was being raised from the bottom. It should be noted that the item "Repairs to Dredge" include only the renewing of broken or worn-out parts, overhauling hulls, etc., and does not take account of delays while adjusting machinery.

ELEVATOR DREDGE MASTODON.

Cost totals for fiscal year 1911-12; dredge working at Alberni and at First Narrows, Vancouver:

Maintenance of—	
Dredge	$53,445.65
Four tugs	9,412.16
Hire of three tugs	27,450.91
Repairs to—	
Dredge	8,036.67
Scows	4,136.87
Tugs	937.66
Total	$103,419.92
Material handled	621,310 cu. yd.
Cost per cubic yard	16 cents

The Mastodon was built by Simonds & Sons, of Glasgow. The dredge is of steel throughout; the length overall is 206 ft.; beam, 36 ft. 6 in.; maximum draft, with the ladder raised, 12 ft. The main engine equipment consists of a pair of compound surface-condensing engines for operating the bucket line or for propelling the ship. These engines are so arranged that either one can be used to drive the elevating machinery. In order to balance wear and facilitate overhaul the bucket line is usually driven by one engine for a week, and then the second engine is used for a similar period. As the engines each develop about 600 i.hp, the operation of the elevator gives only a comparatively light loading. Indicator cards taken while the elevator brought up fifteen loads per minute from a depth of 40 ft. showed an average of 206 i.hp.

Header on Dredge "Fruhling"

There are forty-eight buckets in the elevator. These have a capacity of 24 cu. ft. each and are equipped with manganese-steel replaceable lips. The ladder is long enough to permit operating in depths up to 50 ft., and is said to work satisfactorily in heavy gravel, carrying boulders as large as the buckets will bring up. The Mastodon was purchased primarily for widening the First Narrows at Vancouver, but has been assigned to various other stations where it was required to dredge heavy gravel and small boulders. The large amount of time lost waiting for scows, as shown by Table 2, is chiefly due to the fact that in the First Narrows the tidal currents range as high as 9 knots per hour, which interfered with the speedy handling of scows. The item "Repairs to Dredge" includes alterations so extensive as to amount practically to remodeling, deemed necessary to better adapt the vessel for the work in hand. These alterations were subsequent to the loss of 54.9 per cent of working time for the first month that the Mastodon was in commission, which time was spent adjusting machinery. Since the tabular data were compiled the Mastodon has been converted into an oil burner, and the time lost on account of coaling has become nil. Two months were spent working in exceptionally hard material, some of which was hardpan and rock, which could only be scraped over, and during this time the yardage per hour of actual dredging fell to approximately 280 cu. yd. Due to this fact the average capacity shown is somewhat lower than could normally be expected.

"Trouble with Scows" includes time lost winding up pocket doors in scows by hand power and clearing stones, etc., from hinges. With the ordinary hand-power equipment it took six men 20 minutes to close five pockets, but this was regarded as a serious delay, and all pocket doors have recently been equipped with a compressed-air operating device, designed by Mr. Bayfield, by means of which two men can close the five pockets of a scow in about 2 minutes. Westinghouse compressors are installed on the tugs as well as on the dredge itself, and the usual practice now is for the tug to close the pockets while returning the empty scows.

SCRAPER SUCTION-DREDGE FRUHLING.

Cost totals for fiscal year 1911-12; dredge working at sand heads, at mouth of the Fraser River:

Maintenance of dredge	$35,055.30
Repairs to dredge	10,713.35
Total	$45,768.65
Material handled	669,100 cu. yd.
Cost per cubic yard	6.8 cents

The Fruhling was built in Germany in 1906. Its equipment provides means for elevating material through a pair of centrifugal pumps drawing through pipes from the header or scraper, and delivering to hoppers inside the hull. The length over all is 187 ft. and the beam is 34 ft. 6 in. When the hoppers are loaded to capacity, which is about 800 cu. yd., the draft is approximately 14 ft. 10 in. The vessel is of steel throughout. Twin-screw surface-condensing engines are installed. Each dredging pump has an open runner 54 in. in diameter, fed by a 16-in. suction pipe. They operate at about 200 r.p.m. and are connected to draw from the header, the hoppers or the sea, discharging to the hoppers or overboard.

The Fruhling was purchased primarily for dredging the sand heads of the Fraser River, and the dredging depth ranges up to about 45 ft. In Table 2, the item "Hours Actually Dredging" does not include time lost steaming between dredging site and dumping ground. These points were sometimes 2 miles apart, requiring a 4-mile trip for each load. "Moving to and from place of working" includes steaming from dredging site to shelter for the night, and return, as well as a 16-mile run once a week to New Westminster for provisions and coal. The Fruhling was never worked double shift, but it is Mr. Bayfield's opinion that by converting her to an oil burner and operating double shift her efficiency would be considerably increased.

"Repairs to Dredge" includes the periodical renewal of lining in the main dredging pumps. The life of this lining varies with the material handled, but averages about three months. The original shells on the main pumps were in service for about four years, at the end of

TABLE 1—BRITISH COLUMBIA DREDGING PLANT IN OPERATION AT THE CLOSE OF 1912

Dredges	Estimated present value
Mastodon (elevator)	$210,000.00
Fruhling (scraper-suction)	250,000.00
King Edward (agitator suction)	125,000.00
Ajax (dipper)	120,000.00
Mudlark (dipper)	20,000.00
Nakusp (orange peel)	10.000.00
Pelican (orange peel)	55,000.00
Heron (orange peel)	4,000.00
Bittern (orange peel)	15,000.00
Sheldrake (orange peel)	17,000.00
Snagboats	
Muskrat	6.000.00
Samson	15,000.00
Cygnet	18,000.00
Naas River	4,000.00
Tugs	
Point Grey, 700 hp	69,830.00
Point Ellice, 500 hp	49.000.00
Petrel, 180 hp	25,000.00
Point Hope, 150 hp	17,500.00
Point Garry, 60 hp (gasolene)	9,315.00
Roustabout, 24 hp (gasolene)	3,000.00
Launches	
Athel, 40 hp (gasolene)	5,000.00
Fat Boy, 8 hp (gasolene)	600.00
Fat Girl, 8 hp (gasolene)	600.00
Dotterell, 8 hp (gasolene)	800.00
Lobnitz Rock Breaker No. 1	70,000.00
Submarine drilling plant	8,000.00
Steam lifting scow (Mastodon)	6.400.00
Steam lifting scow (King Edward)	2,000.00
Three 260-cu. yd. dump scows (Mastodon)	36,600.00
Two 300-cu. yd. dump scows (Ajax)	30,000.00
Two 180-cu. yd. dump scows (Mudlark)	17,200.00
Two 150-cu. yd. dump scows	1,000.00
Three flat coal scows	7,000.00
One water scow (King Edward)	1,000.00
Thirty-five pontoons (King Edward)	7,000.00
Hand-power lifting scow (Mastodon)	600.00
Hand-power lifting scow (Lobnitz No. 1)	700.00
Boarding scow (Mastodon)	600.00
Miscellaneous plant (say)	11,000.00
	$1,198,745.00

which period the pumps were replaced by new ones of slightly different design. The original pumps were fitted with nickel-steel liners, but in the new pumps, designed by Mr. Bayfield, the liners are made of "Era" managanese steel, which is said to show less wear.

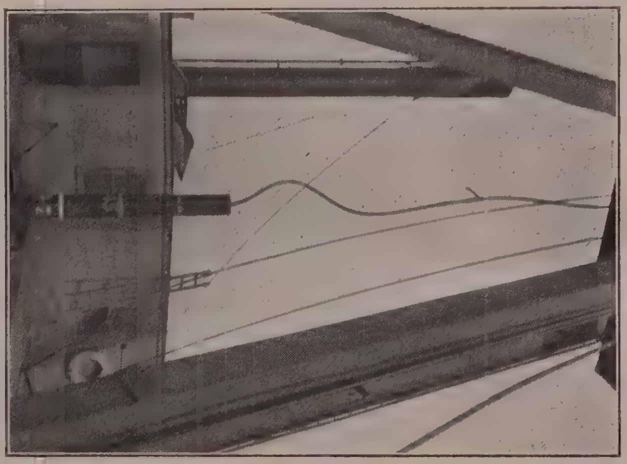
DIPPER DREDGE MUDLARK

Cost totals for fiscal year 1911-12; dredge working in Victoria Harbor:

Maintenance of—	
Dredge	$20,632.27
Two tugs	5.247.52
Repairs to—	
Dredge	7,649.25
Scows	3.628.64
Tugs	1,801.09
Total	$38,958.77
Material handled	90,675 cu. yd.
Cost per cubic yard	42.9 cents

The Mudlark was built at Victoria, B. C., in 1888 and was purchased by the department in 1896. Construction is of wood throughout; the length over all, including crane, is 122 ft.; beam, 30 ft. Three spuds are used to hold the vessel in position, the dimensions of the two bow spuds being 22 x 23 in. x 60 ft., and of the stern spud 15 x 18½ in. x 60 ft. The maximum draft of the Mudlark with spuds raised is 5 ft. 6 in. The dipper has a capacity of 2½ cu. yd. and is operated by a three-part wire hoisting cable. The maximum working depth for this bucket is 40 ft. The dredging engines, which are of the usual double-cylinder type, are used also for raising and lowering the forward spuds. The stern spud is handled by an independent engine, and the crane is swung by a pair of large steam cylinders on the upper deck.

In the period covered by Table 2 the Mudlark as well as the Ajax lost considerable time on account of the water being too rough for the scows to be towed to the dumping grounds, which were about 2 miles distant in the Straits of Juan de Fuca. This is charged to "Time Lost on Account of Wind." The material handled was principally mud. Most of the time the Mudlark worked in confined spaces near wharves, which entailed the loss of some time in the actual operation of the dredge. The cost per yard of material handled in 1911-12 is unusually high on account of the large amount of



Chisel Striking Rock

DIPPER DREDGE AJAX

Cost totals for fiscal year 1911-12; dredge working in Victoria Harbor:

Maintenance of—	
Dredge	$27,951.48
Tug	6,098.18
Repairs to—	
Dredge	10,993.63
Scows	1,574.79
Tug	689.37
Total	$47,307.45
Material handled	154,190 cu. yd.
Cost per cubic yard	30.7 cents

TABLE 2—PERFORMANCE OF DREDGES

Type of dredge	Elevator	Suction-scraper	Dipper	Dipper	Agitator-suction
Name	Mastodon	Fruhling	Mudlark	Ajax	King Edward
Number of months in commission	17	36	36	36	29
Total cu. yd. material handled	951,200	2,597,500	349,275	576,125	1,006,570
Total hours on duty	4,795	8,138	7,982	7,934	6,799.5
Hours actually dredging	2,003	2,386	3,513	3,444	2,786.0
Yd. per hr. actually dredging	464	1,047	98	166.3	366.2
Per cent time actually dredging	39.2	28.9	43.5	43.5	41.6
Per cent of time lost:					
Moving to and from place of working	3.2	11.7	5.2	3.4	3.1
Account repairs to dredge	18.1	22.3	24.2	22.5	25.6
Account repairs to tug	0.6	...	1.9	2.6	...
Account repairs to scows	0.4	...	2.0	1.0	...
Account trouble with scows	10.0	...	1.3	3.2	...
Waiting for scows (tug service)	6.8	...	2.7	1.8	...
Adjusting machinery of dredge	5.0	0.1	2.1	2.0	0.5
Account of wind	0.6	1.2	6.2	4.6	1.0
Account of tide	0.4	0.5	1.0	0.5	1.7
Account of fog	0.9	1.3	0.0	0.2	...
Account of coaling	4.1	5.8	4.0	2.6	1.2
Washing boilers	0.0	2.4	1.3	1.0	2.3
Account miscellaneous causes	10.8	2.4	3.2	4.5	3.2
Discharging hoppers	...	23.0	...	...	...
Taking up and laying out plant	...	...	...	...	15.3
Account trouble with pipe line	...	...	...	...	2.8
Account trouble with pontoons	...	...	...	...	0.1
	For 12 mos.	For 24 mos.	For 12 mos.	For 24 mos.	For 24 mos.
Total cost of operation	$103,419.92	$12.552.33	$30.486.68	$96,493.05	$102,171.14
Average cost per cu. yd	16.6 cents	5.8 cents	20.7 cents	26.2 cents	12.5 cents

TABLE 3—COST OF OPERATION OF DREDGES FOR 12 MONTHS ENDED MARCH 31, 1912.

Dredges	Payroll	Provisions and ice	Boarding equipment	Laundry	Engine-room supplies	Hardware and ship chandlery	Coal ($5½ to $6 per ton)	Water	Drilling supplies	Dynamite	Tug hire	Miscellaneous	Rent of scows	Traveling expenses	New equipment	Repairs to tug	Repairs to scows	Repairs to dredge	Total cost of operation
Fruhling	$15,799.37	$4,266.38	$281.80	$56.25	$1,407.34	$2,129.45	$10,903.56	$21.50	......	......	....	$68.85	......	$15.30	$105.50	....	....	$10,713.35	$45,768.65
King Edward	15,744.76	4,201.59	292.80	72.15	1,353.06	1,733.78	8,171.35	7.05	......	......	$2,740.00	838.35	......	31.45	85.00	....	$1,523.93	6.320.92	43,116.19
Mastodon	22,425.00	7,257.90	731.55	89.65	2,306.87	4,531.61	11,210.68	6.00	......	......	27,450.91	2,684.59	$389.00	88.30	1,724.50	$6.60	4,136.87	8.030.07	93,070.10
Ajax	11,084.47	4.824.95	86.40	43.39	517.93	3,065.67	7,517.20	104.67	......	......	....	504.10	......	......	202.70	....	1,574.79	10.993.63	40,519.90
Mudlark	9,112.48	3,364.62	119.55	30.49	477.72	1,659.46	3,613.50	78.59	......	......	1,150.00	520.86	......	......	505.00	....	3,628.64	7,649.25	31,910.16
Lobnitz Rock Breaker No. 1 (*a*)	3,890.85	1,145.75	73.30	7.82	12.80	894.19	1,196.00	4.80	......	......	373.50	577.08	63.12	3.50	....	....	....	784.21	9,026.92
Submarine drilling plant	7,401.00	......	....	......	10.57	519.08	71.90	......	$983.16	$797.06	....	195.35	......	......	....	....	....	414.26	10,392.38
Snagboats																			
Samson	9,573.81	3,049.01	36.60	93.56	495.55	845.37	2,476.15	......	......	......	....	562.38	......	......	....	....	....	1,986.57	19,119.00
Cygnet	6.539.01	1.967.51	61.11	10.50	....	387.44	1,109.00	......	......	......	....	34.00	......	82.95	....	....	....	97.81	10,289.33
Naas River	2,159.46	858.36	13.75	......	6.22	36.29	118.75	......	......	......	....	1.50	......	......	....	....	....	....	3,194.33
Tugs																			
Petrel	4,347.23	693.32	62.65	......	241.59	707.07	340.30	......	......	......	....	14.10	......	......	....	689.37	....	....	7,095.63
Princess (*b*)	2,155.57	4.50	....	......	32.70	100.76	....	......	......	......	....	....	......	......	....	577.64	....	....	2,871.17
Point Hope (*c*)	1,926.92	62.64	21.05	......	114.67	285.94	60.00	......	......	......	....	482.77	......	......	....	1,223.45	....	....	4,177.44
Point Garry (*d*)	1,916.41	320.92	61.10	12.05	851.46	413.80	....	......	......	......	....	84.50	......	......	265.00	617.81	....	....	4,543.05
Point Ellice (*e*)	2,982.55	1,067.68	....	1.30	255.73	709.71	....	4.00	......	......	....	306.29	......	6.00	....	646.82	....	....	5,980.08
Point Grey (*f*)	584.49	357.35	90.70	......	354.13	459.67	....	......	......	......	....	18.28	......	9.50	....	81.79	....	....	1,955.91
Miscellaneous items	1,297.20	20.88	....	......	49.78	....	....	120.97	......	......	....	212.98	55.50	480.79	441.73	....	....	....	7,640.25
Totals	$118,940.58	$33,463.36	$1,932.36	$417.16	$8,488.12	$18,479.29	$46,788.39	$347.58	$983.16	$797.06	$31,714.41	$7,105.98	$507.62	$717.79	$3,329.43	$3.843.48	$10,864.23	$46,990.07	$340,670.49

a, Only 7 months; *b*, 7 months; *c*, 6 months; *d*, 10 months; *e*, 6 months; *f*, 1 month.

Agitator Suction Dredge "King Edward"

Scraper Suction Dredge "Fruhling"

time the dredge was laid up for heavy repairs.

The Ajax was built in 1908 by the Polson Iron Works, Ltd., of Toronto, and erected by the same firm at New Westminster, B. C. With the exception of housework, the dredge is of steel throughout. The length, including boom, is about 159 ft., and the beam, 38 ft. With spuds raised the draft is 9 ft. The spud arrangement is similar to that of the Mudlark, the Ajax bow spuds being 36 in. square by 66 ft. long and the stern spud of equal length and 30 in. square. Either of two dippers may be used, one having a capacity of 3 cu. yd. and the other 5 cu. yd. The efficient working depth ranges from 15 to 40 ft. The dredging engines are of the ordinary simple twin-cylinder type. Practically all operating gear is driven by steam. This dredge was frequently operated in difficult material, such as hard sand and broken rock, and lost some time on account of cramped positions and harbor traffic. Practically all repairs were made by private firms.

TABLE 4—ESTIMATED ANNUAL COAL CONSUMPTION

Dredges	Consumption, tons,	Cost
Mastodon (tug burned oil)	2448	$14,719
Fruhling (no tug)	1708	11,262
King Edward (gasoline tug)	1600	8,783
Ajax, tug and drill plant	1400	7,700
Mudlark and tug	900	4,950
Snagboats		
Samson	525	3.061
Cygnet	140	1,070
Lobnitz Rock Breaker No. 1	316	2,145
Tug Petrel	300	1,800
Totals	9337	$55,490

The King Edward was built in 1901 by the Polson Iron Works, Ltd., of Toronto, and erected by the same firm at New Westminster, B. C. The length is 125 ft. and the beam is 32 ft. The propelling engines are of the steamboat type, and drive a stern wheel. The 20-in. centrifugal pump used for dredging is operated by triple-expansion, direct-connected engines, operating at 170 r.p.m. The dredging depth ranges from 6 to 45 ft.

AGITATOR SUCTION-DREDGE KING EDWARD

Cost totals for fiscal year 1911-12; dredge working in Fraser River and False Creek, Vancouver:

Maintenance of dredge	$32,531.34
Tug hire	2 740.00
Maintenance of tug (five months)	2,028.54
Repairs to—	
Dredge	6,320.92
Scows and pontoons	1,523.93
Tug	408.76
Total	$45.553.49
Material handled	379.520 cu. yd.
Cost per cubic yard	12 cents

In the period covered by Table 2 this dredge had two serious collisions, underwent an extensive overhaul of the hull itself and received a new dredging pump complete, as well as the usual periodical renewal of linings. The material handled varied from mud to exceptionally difficult sand and gravel carrying boulders. Boulders weighing as much as 180 lb. have been brought up and passed through the pump.

Submarine Drilling Scow

Of course, these would not pass through the pontoon line, and in fact very much smaller stones caused trouble in clogging the pipe. Other pipe-line troubles were caused by tide currents and by the occasional slipping off of the rubber sleeve connections at joints. The large amount of time charged to "Taking Up and Laying Out Plant" is chiefly due to the fact that this dredge was used for a number of short jobs, so that the plant had to be moved frequently.

LOBNITZ ROCK BREAKER No. 1

Cost totals for six months ended March 31, 1912, for work done in Victoria Harbor:

Maintenance of machine	$7,869.21
Tug hire	373.57
Repairs to machine	784.21
Total	$9,026.99
Cubic yards of rock broken (say)	1000
Approximate cost per cubic yard	$9.00

The Lobnitz rock breaker, as purchased from the makers in England in 1910, was arranged for mooring by six cables running to anchors or moorings on shore. After trial in British Columbia, this method was found wholly impracticable because of the difficulty of getting back to the same working position after the cables had been lowered to permit the passage of shipping and because of the large proportion of time lost in manipulating the cables. It was also found almost impossible to hold the vessel steady by this means. Extensive remodeling was therefore resorted to, and three 70-ft. spuds were attached, two at the bow and one at the stern, the drilling well being removed from the center of the machine to a position between the two forward spuds. This remodeling cost about $15,000, but thereafter operation was fairly satisfactory, and the time lost lowering cables and shifting with the tide while vessels passed by was entirely eliminated. A second rock breaker is now being erected for the department, and is being equipped with spuds designed by Mr. Bayfield.

SUBMARINE DRILLING PLANT

Cost totals for fiscal year 1911-12: plant working in Victoria Harbor:

Maintenance of plant	$9,978.12
Repairs to equipment	414.26
Total	$10,392.38
Number of 2½-in. holes drilled	992
Aggregate depth of holes	4442.6 ft.
Quantity of rock blasted (say)	1690 cu. yd.
Cost of blasted rock per cu. yd	$6.13

The rock breaker is equipped with two cutters or chisels suitable for different working depths. The larger of the two, weighing 20 tons, is designed for use in depths up to 40 ft. Each chisel has a detachable projectile steel tip made up with a hard core down the center so as to maintain a fairly sharp point as the tip wears. One of the illustrations shows the cutter just as it strikes the rock. Several photographs were taken of the cutter in this position in the course of a study of causes for cable breakage. At first the cable broke very frequently, and always close to the head of the cutter. This photograph shows the curve in the slack cable, with maximum bending stress near the cutter head. (An account of extensive

Dipper Dredge "Ajax" in Action

Elevator Dredge "Mastodon"

work with rock breakers at Black Rock Harbor, Buffalo, N. Y., will be found in the Engineering Record of Jan. 7, 1911, page 4.)

Drilling Scow

The drilling plant consists of a four-spud scow in which drilling wells are placed on 18-in. centers. A carriage operated lengthwise on this scow is provided with a 5-in. Ingersoll-Sergeant drill, which can be moved laterally on the carriage. The method of operating the plant is to tow the scow to the point where drilling is required and raise it on the spuds until above high-water level. Holes can then be sunk through any or all of the drilling wells up to a depth of 35 ft. below the floor of the scow. Powder is placed by means of tubes passing through the drilling wells, and when all charges are ready the scow is lowered until it can be towed away, after which the charges are fired simultaneously. It has been found most satisfactory to have the boiler for supplying steam to the drill, and in fact all auxiliary equipment, on a small scow floating alongside; thus the entire floor space of the drilling platform is free from encumbrance.

At the close of 1912 an estimate of coal consumption by the various dredges was made, based on experience extending over a period of several years. Table 4 gives the usual coal consumption for a period of twelve months under ordinary operating conditions. The cost is based on coal at about $6 per ton. In this table the dredge Mastodon is the only one for which double-shift coal consumption is estimated.

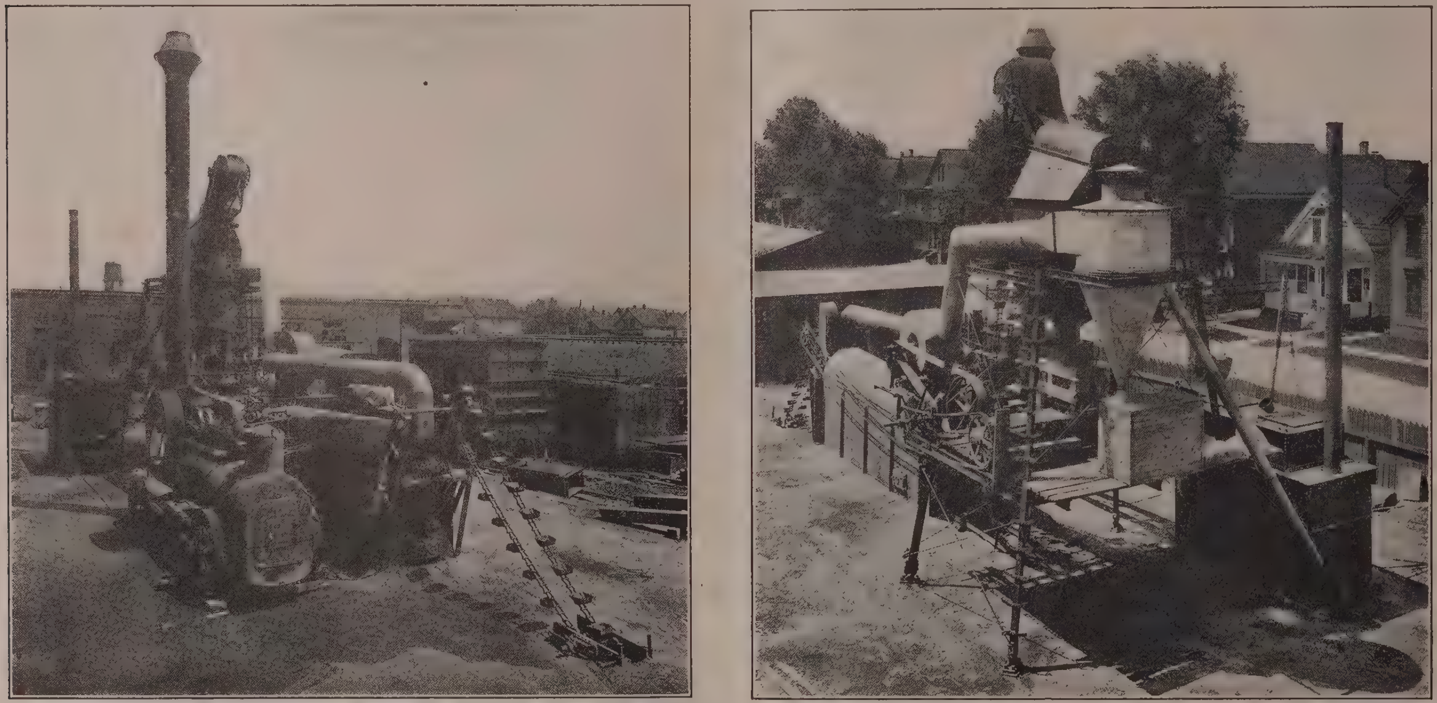
THE MILE POSTS ON HIGHWAYS built by the United States government in the Canal Zone are described in the "Canal Record" as oblong cast-iron plates having raised letters and figures painted white on a black background. Iron rails are used for the standards. The posts were manufactured in the Gorgona shops. Round plates, similar to the markers in all respects except shape, are placed at the road intersections with the Canal Zone boundaries. The posts are set at even miles from the main terminus of each road with distances to other points given in fractional miles.

Semi-Portable Bituminous Mixing Plant

With the increasing use of bituminous macadam and the demand for closer economy and exact methods in asphalt road and street construction the need has been emphasized for a relatively small, compact mixing plant of moderate first cost and minimum expense for maintenance. Such a plant must be suitable for various mixtures and sufficiently portable to overcome the loss entailed in excessively long hauls of the finished mixtures.

To meet these conditions the plant here described has been designed and built at the Iroquois works of the Barber Asphalt Paving Company for the city of Springfield, Mass.

The plant consists of four units—portable boiler and engine, portable single-drum drier, portable melting tank and a mixing tower—which are so arranged that the plant in its entirety can readily be moved and reassembled.



Semi-Portable Bituminous Mixing Plant, Showing Tower, Sand Drum, Dust Collector and Melting Plant

Description of Units

The portable boiler and engine selected for the particular duty to be performed has power in excess of the actual requirements of the plant, thus permitting flexibility in case it is found desirable to increase the normal capacity of the plant. The boiler is of 60-hp, locomotive type, with a 55-hp horizontal engine placed over the boiler shell. The entire unit is mounted on wheels.

The melting kettle has a capacity of 1556 gal. and is a self-contained unit, with a refractory-lined fire unit, fire and ashpit doors, adaptable either for steam or air agitation. This unit is mounted on three 6-in. heavy section I-beams for portability.

The single-drum drier is of the Iroquois standard type. The drum proper is 40 in. in diameter and 20 ft. long, complete with firebrick and asbestos-lined steel setting, firing chamber, double rain roof, elevators, etc. It is a complete self-contained unit mounted on wheels.

The mixing tower is constructed of four main columns consisting of heavy section steel I-beams carrying the necessary platforms, all securely braced with tie rods and turnbuckles. To facilitate dismantling and re-erecting the several members are bolted together. The mixing-tower unit is equipped with a standard 9-cu. ft. Iroquois steam-jacketed mixer, with two sets of shafts and teeth, enabling the purchaser to produce any one of the several mixtures likely to be called for—binder, bituminous macadam, asphaltic concrete or standard sheet asphalt surface mixture. A two-compartment sand bin of a total capacity of 218 cu. ft. is supported between the upper legs of the tower. A rotary screen and cradle is mounted directly over the sand bin, and is equipped with a jacket for the proper separation of the mineral aggregate; the screen can readily be jacketed to meet any modification in the mineral aggregate. The tower carries a dust collector so located that the dust collected is delivered above the line of the top of the mixer, making it available for use as "filler." The necessary accessories, such as weighing box and scale for mineral aggregate, traveler, power fan, "Link-Belt" elevators, etc., are parts of this unit.

The capacity of a mixing plant is limited by (a) the maximum capacity of the mixer employed and (b) the capacity of the drier. In the plant here described the drier has a capacity for handling a scientifically graded cold sand of the composition required for a standard sheet asphalt-surface mixture, containing not more than 5 per cent of moisture, at air temperature 77 deg. Fahr., and delivering same to the conveyors at 350 deg. Fahr., at the rate of 6 tons (12,000 lb.) per hour of continuous operation. The mixer, however, has a capacity of more than double the capacity of the drier, making it possible to double the capacity of the plant by installing an additional drier unit and kettle unit. A superficial square yard of standard sheet asphalt surface mixture, 2 in. in thickness, may safely be assumed to weigh 200 lb. The drum capacity is based on 160 lb. of sand (alone) included in a square yard of surface mixture consisting of sand, filler and asphalt cement. Six tons (12,000 lb.) of sand is the equivalent of 75 sq. yd. per hour or 750 sq. yd. of 2-in.-thick surface per day of 10 hours. On coarser aggregates intended for bituminous macadam or asphalt concrete the drum capacity will materially increase.

Decarbonation of Public Water Supplies to Remove Corrosive Properties

Abstract of Paper by George C. Whipple, Consulting Engineer, New York, Presented at the March 12 Meeting of the New England Waterworks Association

Past efforts to prevent corrosion of pipes carrying public water supplies have been directed, for the most part, toward improving the quality of the metal and the protective coatings of asphalt, coal tar and cement which are commonly applied to the pipe. There is, however, another important phase of this subject—the quality of the water delivered through the pipe. Carbonic-acid gas and oxygen in the water have a very destructive influence on the metal, and if these corrosive properties can be removed, or neutralized, prolonged life of the pipe is assured. Removal of the oxygen is regarded as difficult, expensive and in most cases undesirable, but the elimination or neutralization of the carbonic-acid gas may be accomplished quite readily. It is from the standpoint of the decarbonation of the water that Prof. George C. Whipple discusses the prevention of corrosion. The methods suggested by him consist essentially in aërating the water and adding to it, before its entrance into the pipe lines, lime or soda. In conection with the addition of these chemicals Professor Whipple also considers in detail the question of the hardness of water. An abstract of the paper, which will be discussed at the convention of the New England Waterworks Association in Philadelphia, Sept. 10-12, follows:

Disadvantages of Soft Water

The disadvantages of very soft waters relate to the effect that they have on the pipes through which they are distributed. This brings in two very important problems—lead poisoning and the red-water plague. The primary active agent in causing water to attack lead pipe is dissolved carbonic-acid gas, dissolved oxygen being an important contributory factor. Certain chemical constituents, such as lime, exert a deterrent influence. Investigations in Massachusetts show that in no case is a large amount of lead found in water with a hardness of more than 50 parts per million, and very seldom when the hardness is more than 25 parts per million. Of two waters, one hard and one soft, which contain the same amount of dissolved carbonic acid the soft water would probably have the greater action on lead pipe. Generally speaking, dissolved carbonic acid is higher in ground waters than in surface waters. The problem of lead poisoning has been solved in two different ways—in New England by abandoning the use of lead and in England by removing the carbonic acid from the water.

Experience has taught waterworks superintendents to avoid the use of lead, iron and steel for soft water because of corrosion; to use iron or steel for waters that are quite hard, for reasons of economy; and to use cement-lined or tin-lined pipe for soft waters and waters of moderate hardness that contain carbonic acid.

For many years the practice of hardening the very soft-water supplies of middle England has been common. This is done by adding powdered chalk, or calcium carbonate, which unites with the dissolved free carbonic acid to form calcium bicarbonate, which is soluble. At Sheffield from 15 to 30 parts per million of chalk are applied to the water at a cost of about 52 cents per million gallons. At Birmingham, where the amount of chalk used is a little less than 1 grain per gallon, the hardness of the water is increased about 10 parts per million (from 25 to 35 parts per million). The English method of adding chalk to water neutralizes the free CO_2 and yields $CaCO_3.H_2CO_3$, which remains in solution. Substantially the same results would be reached by adding lime, but chalk in England occurs as a natural deposit and is cheaper than lime. In New England lime would be used instead of chalk for reasons of economy.

Preventing "Red-Water" Plague

The advantages of neutralizing the free carbonic acid of the very soft waters of New England by the application of lime would be to prevent the danger of lead poisoning; to prevent corrosion and tuberculation in water mains; to permit the use of galvanized wrought-iron and steel service pipes under conditions where now it is necessary to use more expensive pipes; and to prevent the red-water plague. Troubles with rusty hot water are less with hard waters than with soft waters, and are greater in proportion to the carbonic acid present. The greatest troubles are found in very soft waters, and especially in soft waters that have been treated with alum and left with a very low carbonate hardness and a considerable amount of carbonic acid. The addition of lime in amounts sufficient to neutralize the carbonic acid normally found would, at the same time, slightly increase the hardness, and the combined results, according to Professor Whipple, would be a very material reduction of rusty water troubles.

Three other advantages of the decarbonation process are mentioned—less need for brass-pipe hot-water systems, less corrosion of boiler tubes and feed-water heaters and, in general, prolonged life of plumbing fixtures.

Possible disadvantages that might result from the treatment are also pointed out by Mr. Whipple. The cost of the water would be slightly increased. In England it is said to have cost between 50 and 60 cents per million gallons for the chalk process, but in this country the cost of adding lime would be greater. The slight increase in the degree of hardness of the treated water would result in a greater use of soap, formation of scale in boilers, slight increase in the color of surface waters charged with vegetable matter and possibly a slight deposition of the calcium carbonate in the pipe if too much lime were used. There is no reason to believe that an increase of hardness from 10 to 20 parts per million would in any way be injurious to the water drinker.

In Professor Whipple's opinion it is by no means certain that decarbonation of natural waters by the use of lime would be desirable, but the method, in his opinion, is well worth trying on a practical scale. It would have to be continued for a few years to determine its merits.

Neutralizing Carbonic Acid with Lime

The amount of carbonic acid in most of the surface water supplies of Masachusetts, as delivered, probably does not regularly exceed 5 parts per million; in ground waters larger amounts are found. To neutralize 1 part per million of carbonic acid with lime increases the hardness 1.14 parts per million. This is the theoretical amount. Actually the increase would be more, as commercial lime is never pure CaO; some of it is sure to be air-slaked when used so that the figures given would have to be increased by indeterminate amounts up to, possibly, 50 per cent. Hence, to neutralize the carbonic acid in ordinary surface water would theoretically increase the hardness by 3 to 5 parts per million, and in some cases by a slightly larger amount.

In the case of swampy waters the increased hardness might be as much as 12 to 15 parts per million, and in ground waters 25 parts per million or more. Waters that contain more than 5 parts per million of carbonic acid may be considered as offering special problems.

Profesor Whipple first considers soft waters where the hardness is less than 10 parts per million and the carbonic acid about 5 parts per million. To neutralize this, CO_2 would increase the hardness of the water about 6 parts per million. The cost of the extra soap involved by this slight hardening would be 60 cents per million gallons plus an additional allowance for air slaking of the lime.

The amount of lime required would be 5.3 lb. of CaO per million gallons for each part per million of CO_2. Water that contained 5 parts per million of CO_2 would, therefore, require 26.5 lb. of CaO per million gallons, or 31.2 lb. of commercial lime containing 85 per cent available CaO. Lime containing relatively small amounts of magnesium would be needed in order not to increase this troublesome element in the water.

To apply the lime as a clear solution would require about 100 gal. of water for each pound of lime, and it would be necessary to have solution tanks in duplicate, as well as mixing tanks and stirring devices. This would require a daily attendance and would be somewhat troublesome in various ways. A better method would be to apply the lime after water-slaking by means of the dry-feed apparatus which has come into sucessful use in some mechanical-filter plants.

A possible advantage of the lime treatment not mentioned previously might be a tendency to check the growth of algæ in distributing reservoirs if the water were treated before entering them. The limitation of carbonic acid would tend to prevent these growths.

Influence of Alum

When alum is used to produce coagulation, as in mechanical filtration, a by-product of the reaction of the sulphate of alumina on the dissolved calcium bicarbonate acid gas, which remains in solution in the water in a condition of supersaturation until the water is exposed to the air. The amount of Co_2 added to the water is 6.8 parts per million for each grain per gallon of alum added, or 4.8 parts per million for each 100 lb. of alum per million gallons of water.

This is a very substantial increase and is the principal cause of the increase in corrosiveness of mechanically filtered water, according to Mr. Whipple, although in the case of very soft water it is probably not the only cause. Although this production of carbonic acid has been known since the early days of the use of alum in connection with mechanical filtration, it has not been considered a matter of sufficient importance to need correction, and as a result many unfortunate cases of red-water plague have occurred. Lately steps have been taken to neutralize the carbonic acid by the use of lime or soda. Alum-coagulated waters thus form a special case, and a very important case, of the general subject under discussion.

Sodium carbonate, Na_2CO_3, known commercially as soda ash, might be used, and sometimes is used, instead of lime to neutralize the dissolved carbonic acid. Soda is commonly used in mechanical filtration when the alkalinity of the raw water is not sufficient to decompose the alum added. Its use posesses some advantages over lime when both are applied as a solution, for soda is more readily soluble than lime, and it does not increase the hardness of the water. As sodium carbonate itself contains carbonic acid and so neutralizes it by one molecule of sodium carbonate combining with one molecule of carbonic acid, a larger quantity of the chemical is required than in the case of lime. This, together with the fact that its cost per pound is greater, makes it more expensive to use. With the dry-feed apparatus in use the principal advantage of soda over lime vanishes, so that in comparing the two the greater cost must be compared with the advantage of not hardening the water. So far as neutralization of carbonic acid is concerned, either chemical is probably satisfactory.

Aeration

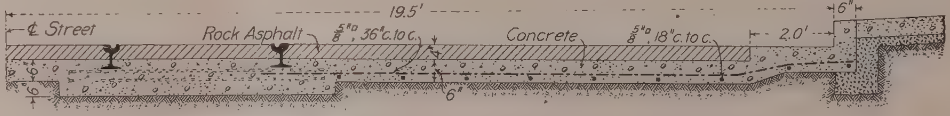
When the amount of dissolved free carbonic acid in water exceeds 5 parts per million its neutralization with lime would be expensive and would increase the hardness of the water by a considerable amount, but when large amounts are present it is possible to reduce them greatly by exposing the water to the air. The amount of CO_2 commonly present in the water is in excess of saturation, so that if the water is exposed to the air in thin films a natural reduction of the dissolved CO_2 will occur. Experiments upon the removal of carbonic acid from water by aëration show that the loss of carbonic acid exposed to the air in drops would be 50 per cent more in summer than in winter. Other tests disclosed the fact that the loss of carbonic acid depends upon the time of exposure rather than upon the distance through which the drops fall. In general it was found that falling drops of water supersaturated with CO_2 require about 15 seconds completely to discharge their excess load of CO_2 into the atmosphere. An exposure of 2 seconds during warm weather ought to reduce the amount of CO_2 from 25 to 30 parts per million to from 5 to 6 parts per million. This is about the limit than can be obtained in practice by aëration in fountains and sprays.

It would be possible to combine aëration by fountains or sprays with the use of lime, utilizing aëration to remove the greater part of the CO_2 and neutralize the small amount left with lime. The alternative proposition would be to prolong the exposure of the water to the air, reducing the CO_2 to the quantity required to saturate it. This would not remove all of the CO_2, but the quantity left would be small. This prolonged exposure could be obtained by allowing the water to fall through holes in a series of trays placed one above the other or to trickle through beds of broken stone, as is done in Germany in connection with the iron-removal process. If this were done adequate ventilation would be all important, for if partial pressure of the CO_2 in the air or the bed or between the trays is increased the solubility of the gas would be raised and the CO_2 would not leave the water.

On account of many unknown factors involved in this problem, Professor Whipple presented the paper without definite conclusions or recommendations.

Rock-Asphalt Paving in San Antonio

About 40,000 sq. yd. of rock-asphalt paving have been laid recently in San Antonio, Tex., where the daily variations in temperature are often as great as 75 deg. Fahr., making any asphalt pavement difficult to maintain. Rock asphalt, containing from 10 to 14 per cent of asphalt in a shell formation, has been mined at Uvalde, 150 miles west of the city, for twenty years, and about 400,000 sq. yd. of pavement have been laid with it. Some of the principal streets in San Antonio paved with rock asphalt twelve years ago are still in a fair state of preservation. The older pavements were laid in one coat, 1½ to 2 in. thick, and compressed with a light roller. It is believed the mixing was not sufficiently thorough nor was the material crushed fine enough to obtain a homogeneous mass. The present plant and method of laying are designed to overcome these difficulties.



Dimensional Half Section of Pavement and Concrete Base

While the old pavement cracks, it seems to iron out without undue disintegration. Tests on the new pavement have been made by piling ice on top of a 4-in. layer with no indications of cracks after forty-eight hours.

Aransas Street and South Alamo Street were paved this spring with two 2-in. layers of the rock asphalt laid on an 8-in. Telford foundation. On South Flores Street a 2-in. layer was placed on a concrete base formerly supporting a worn-out asphalt wearing surface. The cost to the city of the former was $1.37½ per square yard, while the thin 2-in. layer cost 87½ cents per square yard.

Equipment for the preparation of the material comprises two Koehring mixers set side by side with an oil-burning hot blast between them, a crusher with an elevator and two auto trucks. The plant is located alongside a railroad siding so that the rock may be stacked on the ground as it is unloaded.

Crushing is effected best, according to the contractor, with a hammer pulverizer. With jaw or roller crushers the material clings and matts on the faces of the jaws. A Williams No. 2 pulverizer is used, driven by an 85-hp General Electric motor, which also operates the mixers. The crushed material is not run through a screen but is reduced practically to ¼ in. in size or smaller.

The two mixers have capacities of 8 tons each, but ordinarily a charge consists of about 3 to 5 tons, which is heated to a temperature of from 300 to 330 deg. Fahr. in from twelve to fifteen minutes.

In hauling the mixed asphalt to the streets a 5-ton Pierce Arrow and a 3-ton Kelly auto truck, the contractor states, made an average of 7½ miles per hour, while teams are good for 20 miles per day only. With the two trucks material for about 1600 sq. yd. of 2-in. pavement, weighing 200 lb. per yard, was hauled per day.

Laying the pavement was carried out in the same general way as for asphalt, using an 8-ton roller with a 5-ft. base. About twenty men were required to spread the heated material on the street and from twelve to twenty were employed to feed the crusher and tend the mixer.

Where the track of the street-railway company is laid on a heavy concrete base, so that the vibration is a minimum, it is the experience in San Antonio that no serious disintegration occurs at the rails when the pavement is laid next to them. At railroad crossings three lines of creosoted wood blocks are laid alongside the rails. The accompanying drawing shows the cross-section of the street at the approaches to the new concrete slab-and-girder bridge on South Alamo Street, where steel ties of 3-in. I-beams 6 ft. long support the rails.

Over the filled approaches and the bridge the concrete in the foundation was reinforced to prevent unequal settlement. Creosoted wood blocks were laid on the bridge to reduce the dead load.

The work was done under the direction of Mr. A. C. Pancoast, city engineer, by the Alamo Paving Company, for which Mr. J. P. Nelson is superintendent

Crusher Plant Used for the Work

General View of Completed Pavement

Electrolytic Method of Preventing Corrosion

In the hope of developing means for reducing the losses resulting from the corrosion of iron and steel used in mine equipment, the Bureau of Mines has undertaken a thorough investigation of the problem. A preliminary report by Messrs. J. K. Clement and L. V. Walker gives an account of experiments made to develop an electrolytic method for preventing corrosion. The results, the authors believe, appear to justify the hope that the method may be applied successfully in mines for protecting iron and steel against the corrosive action of acid underground waters, as well as for protecting structures and machinery that are exposed to the acid waters of streams.

Electrolytic Theory of Corrosion

According to the electrolytic theory of corrosion, when iron is oxidized in the wet way it first goes into solution as ferrous ions. The ferrous ions are then oxidized by the oxygen present in the water to ferric ions and are precipitated as ferric hydroxide. Simultaneously with the formation of ferrous ions hydrogen is liberated on the surface of the iron. The passage of the iron from the atomic to the ionic state and the passage of the hydrogen from the ionic to the atomic state are accompanied by a transfer of electricity. The ferrous ions derive from the metal surface a charge of positive electricity, the hydrogen ions give up a charge of positive electricity and a current flows through the metal from the point where hydrogen is liberated to the point where iron is dissolved.

If iron and a metal having a greater "solution tension" than iron—for example, zinc—be immersed in an acid solution and connected externally through a wire, zinc will go into solution, hydrogen ions will be liberated on the iron, and current will flow through the wire from iron to zinc. The potential difference between zinc and iron, being opposed to the potential difference between iron and electrolyte, neutralizes the force required to pull the positively charged iron ions away from the negatively charged surface of the iron electrode. Consequently iron does not go into solution.

In place of zinc other conducting materials—for example, carbon—may be used as the anode, and the electromotive force required may be furnished from an external source. In this way electric energy derived from either a battery or a generator may be used to protect metals from corrosion under water.

Description of Experiments

Experiments were undertaken by the Bureau of Mines in May, 1911, consisting of laboratory tests and of studies of plates immersed in the Monongahela River. Steel plates were immersed in a one-fifth normal solution of sulphuric acid, and connected to the negative pole of a storage battery. Carbon rods were used as the other element, and were connected to the positive pole. In a second vessel the steel plate was not protected. After 24 hours' exposure the unprotected plate lost in weight 1.81 gram and the protected plate only 0.0012 gram. In the tests with plates submerged in Monongahela River a much smaller current density was used than in the laboratory experiment, and the protection against corrosion was much less complete. The protecting current was furnished by a 2-volt accumulator. The loss in weight of the two plates at the end of 15 days' immersion was 0.7 gram for the protected plate and 10.9 grams for the unprotected plate.

Later more elaborate experiments were started and the effect of oxygen in the electrolyte, of stirring, acid concentration and potential on the protective value of the current studied. With constant, but not violent, stirring and a sulphuric acid solution one-hundredth of normal strength the plates, having a current density of 0.4 milliampere per square inch or less continued to lose weight during the entire period of the experiments. Plates protected by current densities greater than 0.4 milliampere to the square inch exhibited a marked initial corrosion and thereafter no further loss in weight. The initial loss in weight of the plates protected by current densities greater than 0.4 milliampere is probably due to the fact that at the start of the experiment the plates were covered by a film of air the oxygen of which acted as a depolarizer.

Some time elapsed, therefore, before the plates became completely polarized, and during this period they were incompletely protected by the current. The difference between the rate of loss in weight of the unprotected plate during the initial period and the rate of loss during the remainder of the experiment is probably due to a difference between the structure of the original surface of the metal and the interior, as well as to the action of the film of air surrounding the plate at the beginning of the experiment.

The studies showed that increasing the amount of oxygen in the solution decidedly accelerated the corrosion despite the protecting current, that violent stirring had a similar effect but that the strength of the acid solution, between one-tenth and one-thousandth of normal, had no marked effect.

Electromotive Force

The electromotive force required to maintain a given current density depends on the kinds of anode used, on the position of the anode with respect to the surface to be protected, and on the electrical conductivity of the water. In tests now being made on steel plates submerged in the Monongahela River, at Braddock, Pa., with a distance of about 1 ft. between electrodes, an electromotive force of 5 volts is used. Decreasing the distance between electrodes would permit the use of a lower voltage.

If 1 milliampere per square inch (6.45 milliamperes per square centimeter) be taken as the current density required to prevent corrosion under a given set of conditions, then, with an electromotive force of 5 volts, the power consumption per square foot of protected surface will be approximately 0.75 watt, and the electric energy will be $0.75 \times 24 \times 365 \div 1000 = 6.6$ kilowatt-hours per square foot per year, or 71 kilowatt-hours per square meter of surface per year.

Thus far, therefore, the studies have merely shown that the corrosion of iron submerged in sulphuric acid solutions may be prevented by imposing a counter electromotive force; that the density of the current required to prevent corrosion depends on various factors, the more important being acid concentration, amount of dissolved oxygen, and rate of circulation of the electrolyte; that the current density required can be calculated, within the limit of experimental error, from the loss in weight of the unprotected metal under the given conditions.

The New York, New Haven & Hartford Railroad laid 1,983.296 new ties in the year just passed, as compared with 1,649,231 for the previous year.

Bonus System for the Purchase of Portland Cement

The efficiency of cement specifications and of standard methods of testing have been the subject of a lengthy investigation by the Philippine Bureau of Science. The conclusion reached is that while specifications have improved materially in recent years there is still much room for improvement in order to insure the receipt of cement having constancy of volume and the setting and sand-carrying capacity found desirable in practice. In order to raise the quality a bonus system (not a new idea) has been proposed by Mr. W. C. Reibling, of the Bureau of Science, in the "Philippine Journal of Science."

The weakness of all cement specifications, Mr. Reibling says, is due largely to the lack of definite knowledge concerning the chemical and physical properties of Portland cement. In fact, the results obtained from standard tests are so little understood that they do not enable us to arrange the various products in their true order of merit. Consequently, Mr. Reibling goes on to say:

1. The chief object of testing is defeated, and it is necessary to specify minimum requirements which are intended only to cover the lowest limits which can be allowed on the work and to provide for lack of uniformity in tests as well as in real quality.
2. There is practically no difference between the qualities and properties of a rejected and of an accepted cement in the immediate vicinity of the limit set by specifications; and it is often impossible to avoid the use of inferior material.
3. As quality is specified, the enforcement of cement specifications usually makes it compulsory to award contracts to the lowest bidder regardless of the advisability of purchasing better material at a reasonably higher price.
4. The awarding of contracts to the lowest bidder offers little incentive to produce a higher grade cement than that which will meet the specified minimum requirements. In fact, many manufacturers have to cut down their burning and grinding expenses to the lowest possible figure in order to secure sufficient sales.

Proposed Bonus System

For these reasons Mr. Reibling suggests that Portland cement be purchased as heretofore from the lowest bidder who guarantees to fulfill the requirement of specifications, and that the following provisions be made for bonuses to be awarded for superior quality:

1. No bonus will be awarded unless the cement passes *all* of the specified requirements including perfect soundness after the steaming test and unless the cement is reasonably uniform in quality and suitably packed.
2. A bonus of 10 centavos per barrel will be awarded if the specific gravity is consistently above 3.10 (or the loss by ignition not greater than 2 per cent).
3. A bonus of 10 centavos per barrel will be awarded if the residue on the number 200 sieve is less than 15 per cent, and that on the number 100 sieve less than 3 per cent.
4. Provided the gravity is not less than 3.10 (or the loss by ignition not greater than 2 per cent), a bonus of 10 centavos per barrel will be awarded if the 28-day, 1:3, standard Ottawa-sand briquettes show consistently an average tensile strength above 400 lb. per square inch.

These recommendations provide for the possibility of a well-burned cement with a lower specific gravity than 3.10, if the low gravity is not due to an absorption of volatile constituent, though Mr. Reibling's experience does not include such a possibility.

DISCUSSION OF SCHEME PROPOSED

The above would provide bonuses for superior mixing, grinding and burning, and would permit the manufacturer to earn 30 centavos (15 cents United States currency) per barrel in excess of the selling price. In Manila, 30 centavos is about 5.7 per cent of the usual cost of Portland cement and less than 1 per cent of the cost of concrete. On the other hand, such a system properly enforced ought, in Mr. Reibling's judgment, to secure at least 10 per cent better cement, eliminate the necessity of rejecting cement, and secure greater certainty in its use.

Owing to the varying influences of local conditions in different localities on the cost of manufacture, the values given in this proposed system are not arbitrary. However, the principles constitute the essential features, and they must remain fixed.

Good packing is insisted upon in order to prevent properly stored cement from serious deterioration. Perfect soundness (no warping, checking, cracking or disintegrating after the hot test) is also essential, and it might be advisable, as recommended by Mr. H. J. Force, even to substitute the more severe autoclave test for steaming or boiling under ordinary pressure.

It is useless to insist upon soundness, Mr. Reibling says in his argument, unless we also take into consideration the specific gravity (or the loss by ignition). We can season an unburned cement, or a cement made from poorly mixed or coarsely ground raw materials, until it passes the accelerated tests for soundness; not, however, without a corresponding reduction in the specific gravity and increase in the loss by ignition. Likewise, we can not rely upon the specific gravity or loss by ignition without taking into consideration the soundness. A nonseasoned Portland cement usually has a high specific gravity regardless of whether it is underburned or hard burned and regardless of the amount of free lime at present. Therefore, a bonus is provided for perfect soundness in conjunction with a high specific gravity (or a low loss by ignition) for the purpose of securing a well-burned product.

Another bonus is provided for superiority in strength in order to induce a careful selection and regulation of the raw materials. Ordinarily it woud not be advisabe to base a bonus on the strength developed in twenty-eight days. If a cement contains more than a very small quantity of hard-burned free lime, then no reliance can be placed on the results of the early tests for strength. However, well-burned cements show little or no decrease in strength with age; and, since it is specified that no bonus will be awarded unless the cement is well burned; that is, unless it has a high gravity (or low volatile constituents) and is perfectly sound, no bonus would be granted except for superior permanent strength.

In conclusion, it may be stated that certain manufacturers, to whom the proposed bonus system has been submitted, have expressed their willingness to co-operate on such a basis.

TYPES OF INFLAMMABLE BUILDINGS with inadequate provisions for the safety of the occupants are to be shown in moving pictures at public meetings throughout the State of Arkansas by the Arkansas Fire Prevention Society.

Excavating Lexington Avenue Subway

Unstable Soil on Section 2-A Necessitated Heavy Timbering, Special Drainage Equipment, Underpinning and Sewer Relocation

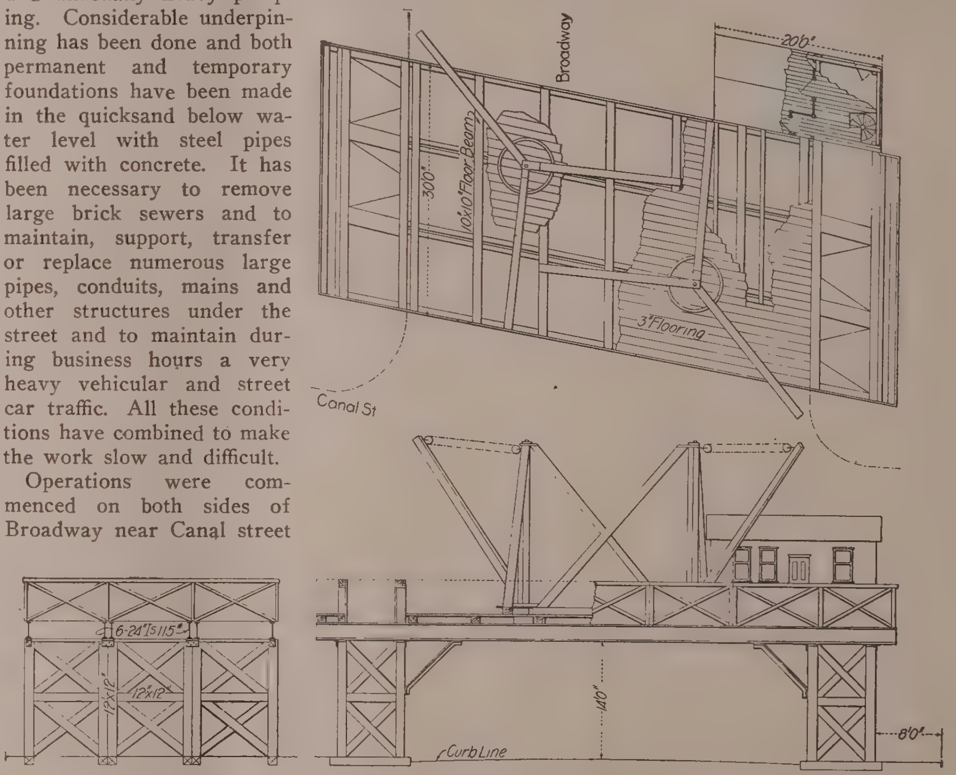
Section 2A of the Lexington Avenue subway, New York, a standard four-track structure located on Broadway and Canal Street, requires an excavation from 62 to 80 ft. wide and from 33 to 49 ft. deep through sand clay and small boulders. A large amount of ground water which, at the commencement of operations, was only about 7 ft. below the surface of the street, was encountered. Like the other subway work in this vicinity, construction is carried on in a covered trench, and materials are handled in and out by derricks installed on elevated platforms extending across the street and supported by towers at the curb lines.

The unstable soil necessitated heavy timbering in the trench, special drainage operations and unusually heavy pumping. Considerable underpinning has been done and both permanent and temporary foundations have been made in the quicksand below water level with steel pipes filled with concrete. It has been necessary to remove large brick sewers and to maintain, support, transfer or replace numerous large pipes, conduits, mains and other structures under the street and to maintain during business hours a very heavy vehicular and street car traffic. All these conditions have combined to make the work slow and difficult.

Operations were commenced on both sides of Broadway near Canal street by the excavation of two 8 x 30-ft. pits 3 ft. deep on the sidewalk sides of the curb lines. The towers for the overhead derrick bridge and hoisting shafts were built in them and at each end of the excavation an 8 x 8-ft. pit was carried down to a depth of 5 ft. and six vertical shores set in it to support the tower sills. The main excavations were then sheeted down to the bottom of these pits and protected by solid enclosing fences 6 ft. high.

After the street pavement between these excavations had been removed at night and replaced by a 4-in. wooden deck laid on longitudinal stringers the excavations on both sides of the street were connected by drifting under the deck with top headings about 11 ft. deep. The towers for the derrick platform were underpinned and the excavation was carried to sub-grade, thus providing a full depth transverse cut or heading from which the general excavation progressed under Broadway in opposite directions.

Full-width upper headings, about 7½ ft. deep, were first driven and followed by the underpinning of adjacent buildings, the driving with air hammers of 3-in. tongue and groove sheet piling and the excavation of a second full-width lift about 7½ ft. deep, carrying the bottom down about 15 ft. below the surface of the street. At this level the ground which is below the original ground water line is so soft and poor that unusual provisions are required to safeguard and expedite the work and 20-in. steel pipes, 6 ft. long, in three sections each, are driven in the planes of the transverse bents of timbering which support the street deck. Concrete is placed in the bottom of each pipe to form foundations on which 12 x 12-in. vertical shores are set to support the bents and make them secure when the excavation has been carried completely down around them.



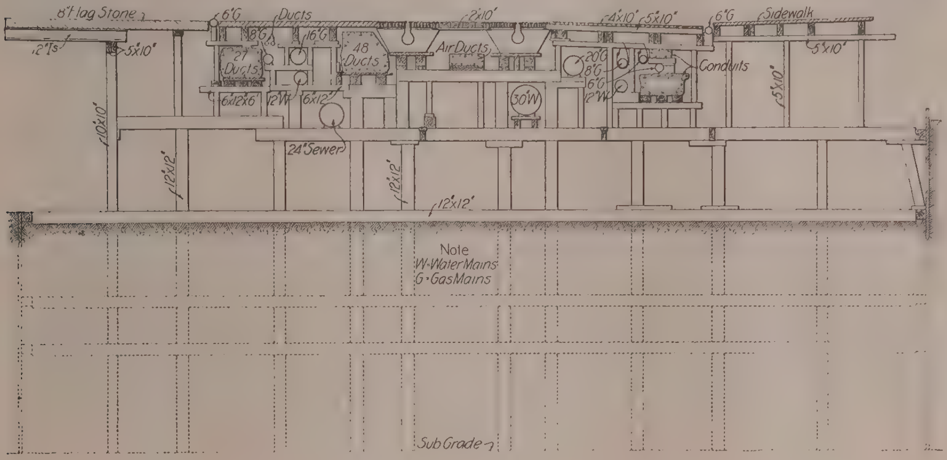
Shaft Towers and Overhead Street Bridge and Derricks; Tower Foundations Omitted

After these pipes were driven a longitudinal trench 10 ft. wide and 7 ft. on centers from the center line of Broadway was sheeted down to a depth of 28 ft. below the surface of the street thus forming a continuous sump in which several pumps were located. These pumps drained the ground on both sides, which will be excavated to sub-grade in three successive lifts while the central trench is being carried down in advance. All of the material excavated is shoveled into buckets and pushed to the hoisting shaft on three longitudinal tracks.

PUMPING

As soon as excavation was commenced a large quantity of water was encountered. This water has been controlled, its level lowered about 20 ft., and the condition of the soil greatly improved by the draining and pumping system. Advance wells consisting of 12-in. pipes sunk to a depth of about 80 feet have been driven to act as casings for 10-in. pipes with copper strainers 20-ft. long at the bottom. The 12-in. pipes are removed and the 10-in. pipes connected to the suctions of 8-in. centrifugal pumps operated continuously. There is now in operation a battery of twelve pumps, most of them driven by General Electric motors, which discharge 15,000 gal. of water per minute into the sewers against a maximum head of about 30 ft.

Part of the pumps are connected to the wells, and part of them to open sumps carried down as the work progresses to a level 1 or 2 feet below that of the general excavation. Most of the sumps are 8 x 8-ft. shafts sheeted with 3 x 12-in. tongue and groove planks driven by power hammers. At the bottom of the sump a 4 x 4-ft. wooden box is carried down 2 or 3 ft. farther. One sump is sheeted with 12-in. United States steel sheet piles, 16 ft. long, driven in two sections each with staggered butt-joints about 1 ft. apart. A 15-in. pipe about 12 ft. long is driven in the bottom of this sump and collects the water through numerous 3/8 x 3/32-in. perforations in the lower end above 2 ft. of broken stone filling. The water rises with some force through this pipe which acts as a sort of vent, and with the driven wells prevents boiling of the sand in the bottoms of the sumps.



Method of Supporting Subsurface Structures during Subway Excavation

UNDERPINNING DERRICK PLATFORM TOWERS

When the second lifts of the hoisting shafts were excavated, longer shores were placed under the tower sills, and were supported on 12 x 12-in. transverse sills on the bottom of the excavation 16 ft. below the surface. These sills were jacked up and under each end there were placed two 15-in. longitudinal I-beams bolted together with separators to form long stringers 7 ft. apart on centers to carry the shaft towers. Outside of each stringer, in the planes of the tower bents 10 ft. apart, there were driven three 12-in. steel pipes, six on each side of Broadway, to carry the tower foundations well below sub-grade.

The pipes were driven in sections of convenient lengths, connected by inside couplings, and the sand was excavated from the interior only down to sub-grade. Above this point the pipe was concreted, the intention being to cut the pipe off at sub-grade and remove the upper part, leaving about 10-ft. of pipe abandoned in the ground below sub-grade after the construction is finished. Each pair of pipes, 10 ft. apart transversely, was capped with a 6 x 12-in. transverse timber, supporting two 6 x 12-in. longitudinal caps on the pipe centers and a second set of 6 x 12-in. transverse pieces which received the 15-in. longitudinal stringers, and thus provided support for the shaft towers and overhead platform that was independent of all excavations above sub-grade.

DIVERSION OF SEWAGE

On Canal Street there is a brick sewer 10 ft. wide and 6 ft. deep, discharging into the North River and receiving 4 ft. x 2 ft. 8 in. and 4 ft. x 3 ft. 8 in. branches entering it with curved connections at Broadway. The invert of the large sewer was about 10½ ft. below the surface of the street, and when the top of the sewer was exposed by the excavation it was removed and 20 and 25-ft. sections of 36-in. flanged steel pipe were inserted and pushed upstream in the sewer to permit other sections to be added and so on until about 250 ft. of pipe was placed there to replace that section of the sewer within the limits of the subway excavation.

As the sewer had been partly superseded the small flow through it did not seriously interfere with the connections of the flange joints. After the pipe was connected the upper end was temporarily enclosed in a sand bag cofferdam and the flow diverted to the pipe, permitting the brickwork below that point to be removed, while the sewage was carried through the steel pipe to the undisturbed lower part of the brick sewer.

Similarly the small brick sewers were replaced by sections of 24-in. spiral-riveted flanged pipe, all of which were inserted through a break made in the sewer and pushed forward as the work advanced upstream. Considerable difficulty was experienced in connecting these branches to the Howard Street sewer because the radius of curvature was so short that only very short pieces of pipe could be used and the regular Y fittings and eighth bends did not exactly conform to the alignment, making it necessary to correct them by the insertion of dutchmen or wedge-shaped rings of soft wood with rubber gaskets which served successfully to give the required angle and make tight joints.

The brickwork in the inverts of the sewers was found to be very poor, with scarcely any evidence of strength in the mortar, thus permitting considerable leakage which, when a heavy rain storm occurred, was greatly augmented and caused considerable scour, eventually breaking through a portion of the sewer where the curved connection was being established, washing out the bulkhead and flooding the excavation. The volume and pressure of the water was so great that it seriously threatened the shores and other timbering in the trench and active measures were immediately taken to protect the latter by riprap of sand bags and broken stone which were also used to form the banks of a sort of channel directing the flow as much as possible to a large 8-in. emergency pump.

An extra long section of 24-in. pipe was used to bridge over between the end of the by-pass and the broken part of the brick sewer, a new bulkhead was built in the latter, and the service was maintained temporarily.

SHAFT TOWERS AND DERRICK PLATFORM

The shaft towers each have six 12 x 12-in. vertical posts seated on the sills and foundation pipes already described, and X-braced both longitudinally and vertically. They are 47 ft. apart in the clear and support on their longitudinal caps six 24-in., 100-lb. I-beams, 70 ft. long, which cross Broadway 14 ft. high in the clear above the street. The center girders are bolted together in pairs with separators, and each of them affords direct support to a stiff-leg derrick with a 20-ft. boom which commands the 6 x 8-ft. hoisting shaft adjacent to which, on each side of the street, there are two 20-yd. hopper bottom storage bins into which the spoil is dumped from the buckets and from which it is chuted to the wagons in the street.

The design and construction of the subway are under the direction of the Public Service Commission, of which Mr. Alfred Craven is chief engineer, Mr. Robert Ridgway, engineer of subway construction, and Mr. J. O. Shipman, division engineer. The general contract for this section is being executed by the O'Rourke Engineering Construction Company, Mr. John F. O'Rourke, president. A large plant has been installed and excavation is carried on during the eight-hour day shift, timbering and other auxiliary work during both day and night shifts, and pumping is maintained continuously. The total force of about 250 men is under the direction of Mr. John Kirgan, superintendent, and Mr. John J. Dooley, engineer.

War Department Recommends Atlantic Coast Canals

The acting Secretary of War has recommended to Congress the spending of approximately $30,000,000 for Atlantic intercoastal canals. The plan proposed contemplates the purchase, at a sum not exceeding $2,514,290, of the Chesapeake and Delaware Canal connecting the Chesapeake and Delaware Bays, its transformation to a 12-ft. sea-level canal at a cost of about $8,000,000, and the construction at an estimated cost of $20,000,000 of a 12-ft. lock canal from the Delaware River to New York Harbor, capable of future enlargement to a 25-ft. sea-level canal.

Two committees of army engineers have been investigating the matter. A special committee, of which Col. William M. Black was chairman, recommended a 25-ft. sea-level canal, 125 ft. wide at the bottom, between the Delaware River and New York Harbor. It is estimated that this would cost $45,000,000, and the Board of Engineers for Rivers and Harbors, of which former Colonel William T. Rossell was chairman, concluded that a 12-ft. lock canal with a 90-ft. bottom width would meet present needs, and that is substantially the recommendation of former Brig.-Gen. William H. Bixby.

General Bixby's report advises immediate starting of the work if a suitable right-of-way can be obtained, and he asks an immediate Congressional appropriation of $500,000, with other annual appropriations sufficient to allow completion of the work in eight years.

The San Francisquito Power Station No. 1

High Head Development on the Los Angeles Aqueduct, Receiving Water Through Riveted Steel, Lap-Welded and Banded Lap-Welded Penstocks

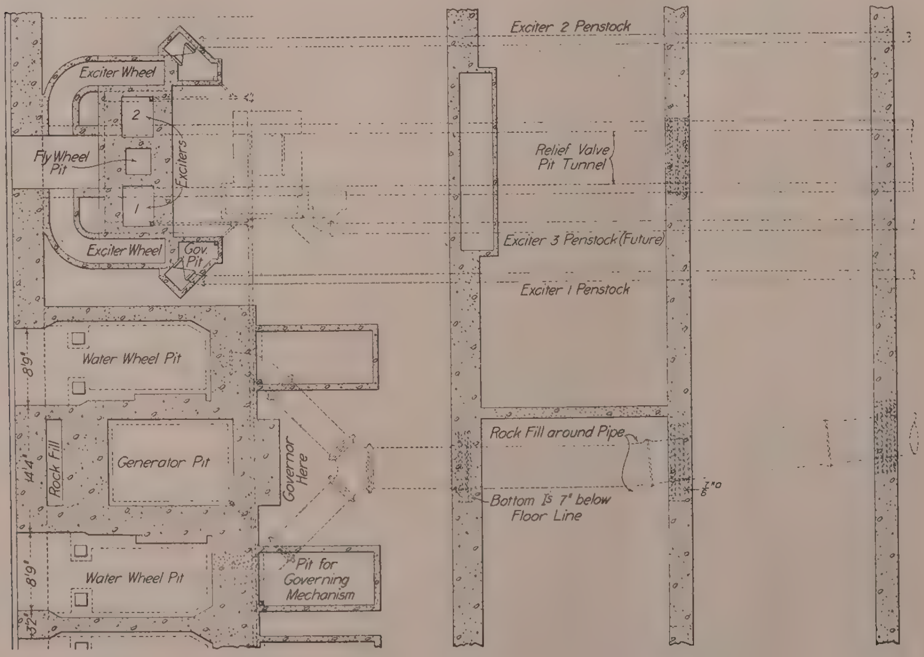
Seven municipal hydroelectric power plants will ultimately be constructed at advantageous points on the Los Angeles aqueduct. The hydraulic grade of the aqueduct at the intake in Owens Valley is 3812 ft. above sea level, 2647 ft. above the reservoir in the San Fernando valley. Of this drop 1829 ft. will be utilized as the net head by the wheels in four power plants, located 162, 47, 40 and 24 miles from the city. There are also three smaller plants of 600, 1500 and 2500-kw capacity on creeks near the upper end of the line, the first two of which were built to supply energy for construction purposes. The ultimate development will deliver an average of 48,000 kw or 64,000 hp continuously throughout the year, with a maximum peak each day of 90,000 kw or 120,000 hp.

At present work is progressing on the largest unit, the San Francisquito station No. 1, 47 miles from Los Angeles, at the end of the 8-mile Elizabeth tunnel through which the water passes under pressure from the Fairmont reservoir and then drops through steel penstocks. The static head is 941 ft. Three 14,000-hp units are being installed in the present power house where space is provided for a fourth. This building will ultimately house six similar units.

The plant has been designed to conform with the ultimate development, and the assumption has been made that the aqueduct would have to carry 400 sec.-ft. of water each day whether power is developed or not. A steady development of 14,000 kw, an amount expected to represent the minimum demand, is assumed by all plants except the two in San Francisquito Canyon. In addition the power requirements to accommodate the variable demand during the remainder of the day, which, from curves worked up by the chief electrical engineer, will vary from 0 to 76,000 kw, will be met by the two San Francisquito plants. The required flow of water, therefore, will vary, under the available heads, from 0 to 1000 sec.-ft., while, at the same time, the amount passed each day must average 400 sec.-ft., as in other parts of the aqueduct. Fairmont reservoir above and Dry Canyon reservoir below these plants, with capacities of 7620 and 1325 acre-ft. respectively, will permit this variation, and the tunnels and siphons were therefore given the necessary cross sections and slopes to pass 1000 sec.-ft. This arrangement is designed to provide for the close adjustment of power output to demand, and, within the rated capacities, to obviate the necessity of any steam auxiliary either for relay or for carrying peak loads.

Regulation of the varying flow through the 8-mile tunnel to avoid possible water hammer, pressure waves, or sudden change of head is provided for by the construction of a surge chamber over the end of the tunnel at the head of the penstocks. When passing 400 and 1000 sec.-ft. the loss of head through the tunnel will be 36 and 127 ft. giving effective heads on the wheels of 905 and 814 ft. respectively.

View of Partly Finished Power-House Substructure and Penstocks



Plan of Power Station Indicating Substructure Arrangement for Main Unit

Penstocks

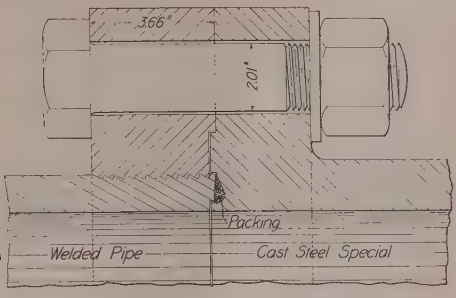
Ultimately three 7-ft. steel penstocks will carry water at 8½ ft. per second maximum velocity from the surge chamber to regulating needle valves located on a natural plateau 258 feet above the power house. At this point each line branches into two 4-ft. 9-in. pipes, each feeding a separate water wheel. At present two of the larger and three of the smaller sized pipes are being installed.

Downstream from the butterfly gates beyond the surge chamber the 7-ft. penstocks are laid on a ridge. For 2215 ft. the pipes are above ground on concrete piers, and for the remainder of the distance, 1138 ft., the 4 ft. 9-in. pipes are laid in trenches and back filled. The first section, 1378 ft., is made up of butt-jointed riveted pipe, varying in thickness from ⅜ to 9/16 in.; the joints are provided with from double to quadruple-riveted butt straps. Lap-welded pipe, varying in thickness from 11/16 to 1¼ in. thick, is then used for a length of 817 ft. Except for thicknesses above 1 3/16 in. the manufacturers, Aktiengesellschaft Ferrum, of Kattowitz, Germany, did not recommend welding, so that ⅝-in. shells, banded with 1⅜ x 5-in. bands, were shrunk on the pipe 6 in. apart.

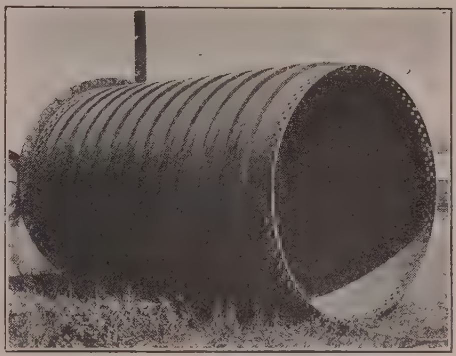
Taking everything into consideration, it was found cheaper to branch the 7-ft. pipe near a comparatively level space. This site also was the most feasible, topographically, for the control valves, so from this point each 7-ft. line was branched to a 4 ft. 9 in. size of lap-welded pipe, which varies in thickness from ⅞ to 1 1/16 in. for 732 ft. and is then reduced to 4½ ft. diameter, 1 1/16 and 1⅛ in. thick for 364 ft. The Treadwell Construction Company, of Midvale, Pa., manufactured the riveted steel pipe.

Joints on the lap-welded pipe are of the ball and socket double riveted type, or what is known as the "bump" joint, the spigot being enlarged and rounded back of the end while the socket is flared. Connections of the banded pipe are made by very heavy double riveted butt straps. Flanged connections to cast-steel specials are made as shown in the drawing, a continuous rubber ring packing

Lap-Welded Pipe with "Bump" Joints



Joint Used for Penstocks



Length of Lap-Welded and Banded Pipe

being used to obtain absolute water-tightness.

Just beyond the branches are located the Pelton needle valves, hydraulically operated from pilot valves in the power house under pressure from the penstocks. The needle valves are manipulated under a maximum head of 678 ft.

Three vent valves admit air into the pipes in case of draining. One is located near the butterfly valves, one at the top of the slope and the third just below the needle valves where an air outlet valve also is located.

Expansion joints on the 7-ft. pipes, which are entirely above ground, are located at three points immediately below heavy anchorage blocks of concrete, designed to take the thrust due to a change in temperature of 110 deg. This variation will be reached only during the construction period and when the pipe is empty. These joints are of the piston type, permitting a total movement of 1½ ft.

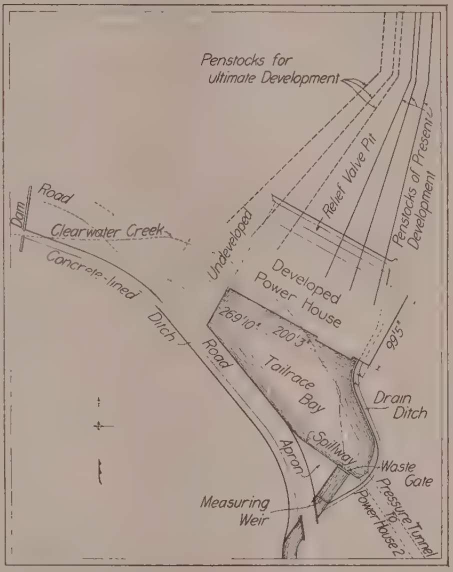
Cast-iron saddles, with the bearing face shaped to the proper angle to fit the pipe, are grouted into the concrete piers and support the pipe at 20-ft. intervals.

As the pipes below the needle valves are buried in the ground it has been assumed that the temperature stresses will adjust themselves in the pipes.

Placing the Pipes

The pipes and the machinery, the heaviest piece of which weighs 15 tons, were hauled from Saugus, 17 miles away by teams of ten or more mules, using wagons and trailers with 8-in. tires. The pipes were rolled to place, or over the trenches on timbers, and then let down to line and grade by jacks.

A standard gauge track was constructed along the line of penstocks and motive power furnished by a 75-hp hoisting engine installed above the plateau, where the needle valves are located, and a 100-hp hoist at the head of the penstocks. The pipes and other materials are hauled up the grade on a small flat car by a 1-in. Pacific wire rope. Tracks are laid down the line of each penstock, so that a car loaded with a pipe section can be switched at the top and let down to place.



Location Plan of Power Plant

A reinforced concrete power house, 99½ x 200 ft. in plan, is now being constructed at the foot of the ridge at a sharp bend in Clearwater Creek, which will carry the flow of the aqueduct until the power development has been completed. The setting of the wheels, a section of the power house and a general location plan are shown in the drawings.

The Westinghouse generators have a rated capacity of 7500 kw under an 0.8 power factor. They are set on a horizontal shaft with a Doble impulse wheel on each end. The two wheels, which together are rated at 14,000 hp, are controlled by Lombard, type F, governors. Under sudden load releases the auxiliary nozzle below the wheel opens, and the jet strikes a vortex baffle designed to use up the energy. Protection of the penstock line is effected by the surge chamber, the synchronously operated governors opening the second nozzle; in case more relief becomes necessary a relief chamber has been provided back of the power house in which automatic valves may be installed on the penstocks.

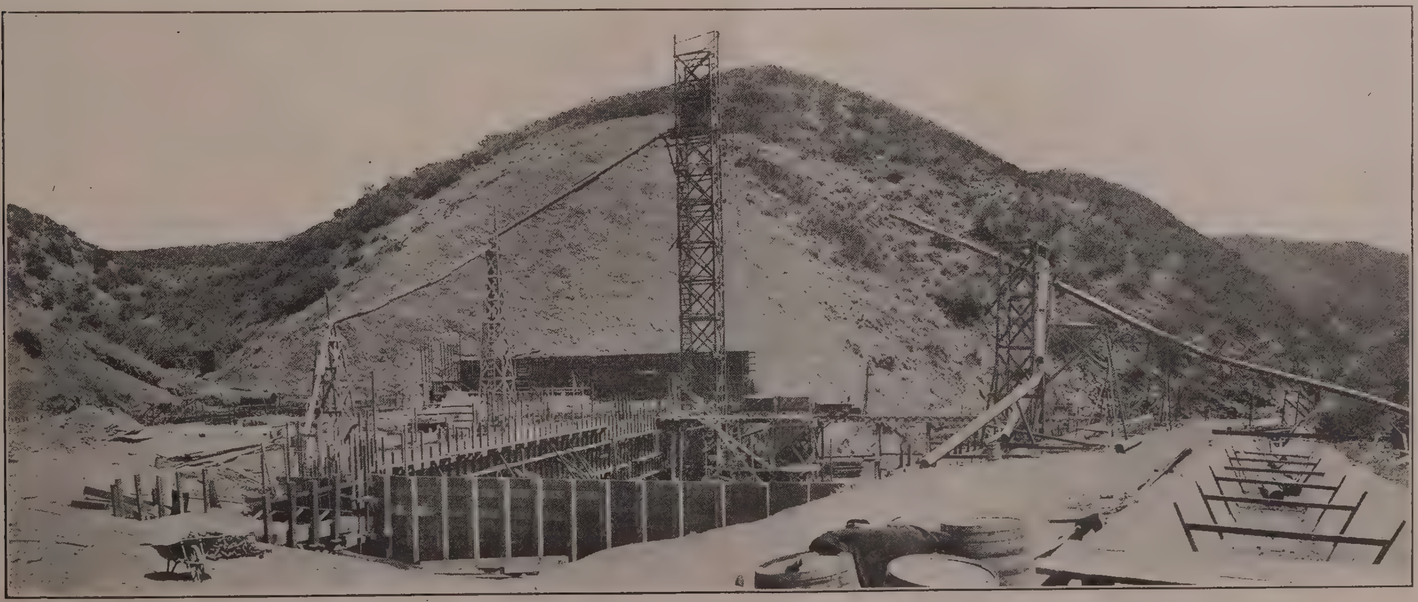
Current will be generated at 6600 volts and stepped up to 106,000 volts for transmission. Nominally this is a 100,000-volt system.

A Shaw 50-ton electrically operated crane serves the generator room and an industrial track in front of the transformers will permit transferring these heavy units on trucks.

The building is constructed on solid rock foundations and is of concrete throughout. The 2½ and 3-in. roof slabs are reinforced with Hy-Rib and the large windows are provided with Mesker steel sash.

Tailrace

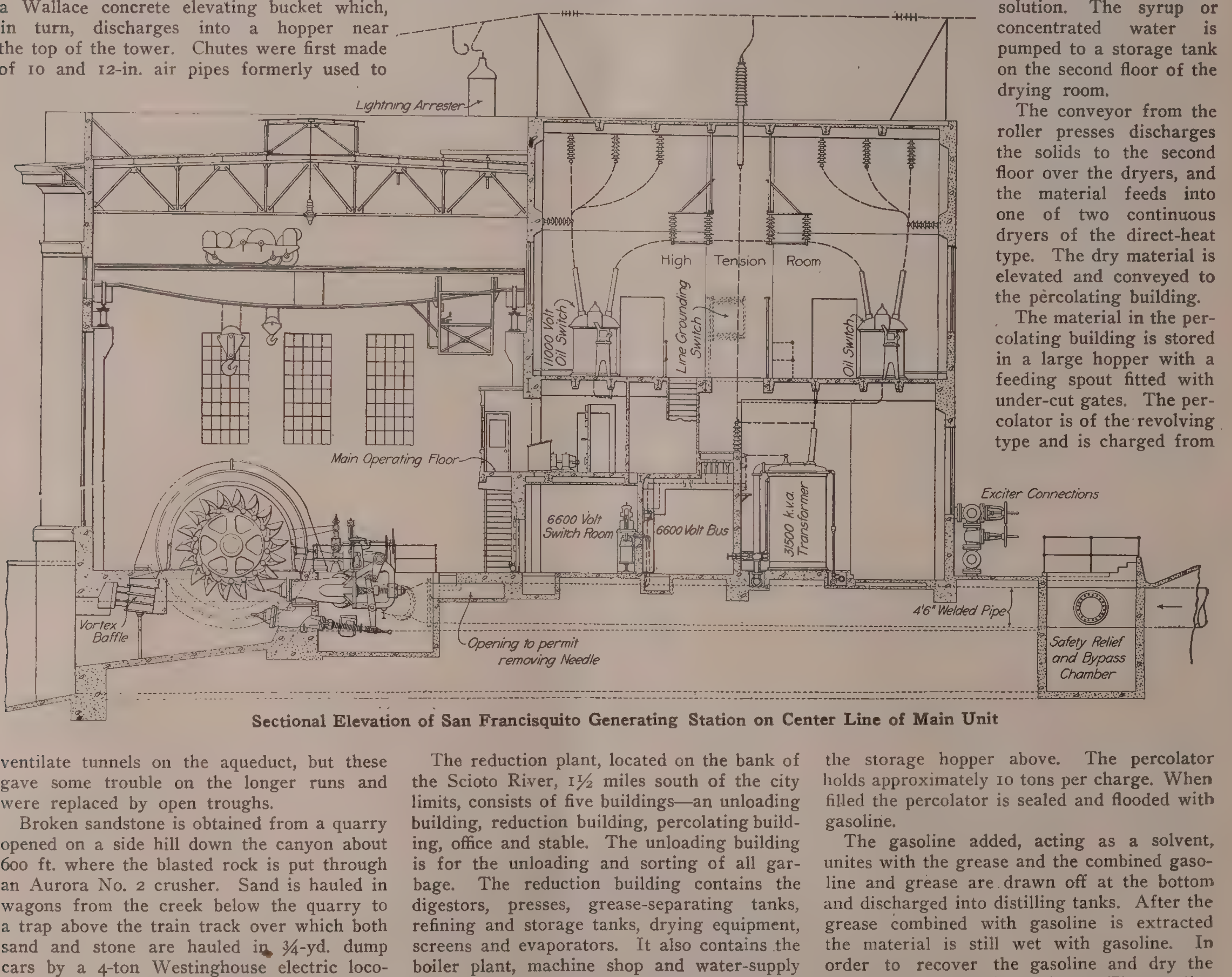
A trapezoidal-shaped tailrace, 20 ft. deep, beyond the power house serves also as a forebay for the tunnel leading to the second San Francisquito plant. It is built in the bed of the creek, the excavation being carried into solid rock



View of Power House Substructure, Showing Method of Placing Concrete; Tail Race to the Right floored over with concrete. A reinforced concrete buttressed wall separates the tailrace from the road and the concrete lined ditch carrying the creek flow. At the lower end is a spillway, 70 ft. long, designed to discharge 1000 sec.-ft., two 6 x 7-ft. sluice gates and a 15-ft. measuring weir. Racks at the entrance to the tunnel are placed for safety with the 3/16-in. bars 2 in. apart. Stop log grooves are left in the tunnel entrance so the flow may be shut off to allow inspection and to divert water to the creek during construction.

Construction Plant

A concrete mixing plant is located in the tailrace near the center of the south power house wall. Over it a tower 110 ft. high has been erected of 8 x 8-ft. bents. A 1-cu.-yd. motor driven Ransome mixer discharges into a Wallace concrete elevating bucket which, in turn, discharges into a hopper near the top of the tower. Chutes were first made of 10 and 12-in. air pipes formerly used to ventilate tunnels on the aqueduct, but these gave some trouble on the longer runs and were replaced by open troughs.



Sectional Elevation of San Francisquito Generating Station on Center Line of Main Unit

Broken sandstone is obtained from a quarry opened on a side hill down the canyon about 600 ft. where the blasted rock is put through an Aurora No. 2 crusher. Sand is hauled in wagons from the creek below the quarry to a trap above the train track over which both sand and stone are hauled in ¾-yd. dump cars by a 4-ton Westinghouse electric locomotive formerly used on the aqueduct tunnels.

The development is carried out by the Bureau of Los Angeles Aqueduct Power of the Board of Public Works, Mr. William Mulholland, supervising engineer; Mr. E. F. Scattergood, chief electrical engineer; Mr. T. A. Panter, chief assistant engineer in charge of design, and Mr. H. C. Gardett, assistant engineer in charge of construction. All work at the power plant is done by force account.

Portable Electric Lamps for use in mines are being investigated by the Bureau of Mines. The bureau believes that the safety of mining operations will be largely increased by the abandonment of flame lamps.

Operation of Columbus Garbage Reduction Plant

The municipal garbage-reduction plant at Columbus, Ohio, whose operation was discussed in the Engineering Record of Dec. 9, 1911, page 689, handled an average quantity of 60.03 tons per day during 1912, and the receipts exceeded the operating costs, exclusive of fixed charges for interest and depreciation, by $1.24 per ton. The works have been in charge of Mr. Irwin S. Osborn, and the following operating data are from his latest annual report.

The garbage is collected in steel-bodied wagons and hauled to a central loading station, where it is transferred to cars, which are delivered to the disposal works each evening.

The reduction plant, located on the bank of the Scioto River, 1½ miles south of the city limits, consists of five buildings—an unloading building, reduction building, percolating building, office and stable. The unloading building is for the unloading and sorting of all garbage. The reduction building contains the digestors, presses, grease-separating tanks, refining and storage tanks, drying equipment, screens and evaporators. It also contains the boiler plant, machine shop and water-supply pumps. The percolating building contains percolators for extracting grease, refining and distilling tanks for recovery of gasoline.

Handling Garbage

The garbage when delivered at the plant is weighed and run into the unloading building. The body of the car is then turned on trunnions by means of power hoists and the contents are discharged on the floor below. The free water is drained off through gutters leading to grease-separating tanks. A scraper conveyor discharges the garbage directly into the digestors.

The digestors are eight in number, 7 ft. in diameter and 14 ft. long. The capacity of each is 10 to 12 tons. The digestors, when filled, are sealed and steam is admitted at the bottom for cooking. When cooked the garbage is discharged into a receiving hopper directly connected with a roller press. The material, as it passes through the press, discharges the solids at the front into a scraper conveyor and the grease and water flow from the rear of the press through a conduit into catchbasins in the grease-separating room.

The water and grease are pumped from the catchbasin into a battery of tanks, where the grease is separated by gravity and drawn off into treating tanks, from which it is pumped to storage tanks ready for shipment. The tank water, after the grease is recovered, flows to a storage tank, from which it is pumped to a triple-effect evaporator and is concentrated to a syrup so as to recover the solids in solution. The syrup or concentrated water is pumped to a storage tank on the second floor of the drying room.

The conveyor from the roller presses discharges the solids to the second floor over the dryers, and the material feeds into one of two continuous dryers of the direct-heat type. The dry material is elevated and conveyed to the percolating building.

The material in the percolating building is stored in a large hopper with a feeding spout fitted with under-cut gates. The percolator is of the revolving type and is charged from the storage hopper above. The percolator holds approximately 10 tons per charge. When filled the percolator is sealed and flooded with gasoline.

The gasoline added, acting as a solvent, unites with the grease and the combined gasoline and grease are drawn off at the bottom and discharged into distilling tanks. After the grease combined with gasoline is extracted the material is still wet with gasoline. In order to recover the gasoline and dry the material live steam is admitted. The gasoline passes off as a vapor through a vapor line connected with a condenser, where is it is condensed and returned to the storage tanks for future use.

The tankage or dry material is discharged from the percolator and conveyed back to the second floor of the drying building, where it is screened to remove rubbish or foreign material.

The tankage from the screen is then mixed with the concentrated tank water recovered in the evaporator and then passes through the dryer, so that all the solids originally contained in the garbage are combined in a dry state. After final drying the material is elevated to storage or loaded into cars for shipment.

OPERATION DURING 1912

During 1912 the drying equipment was changed from steam to direct-heat dryers. This work consisted in the removal of two vacuum mixing dryers, the installation of one new direct-heat dryer with necessary furnaces and chambers and the rebuilding of the revolving steam dryer. The change made resulted in doubling the capacity of the drying equipment and permits the drying of all material during the day shift of eight hours. It also permits the drying of material at less cost for labor, fuel and supplies. Tests were made in the treatment of gases and methods were developed for deodorizing them. Deodorizing condensers are being installed and provision is being made for deodorizing all gases in high-temperature furnaces.

The addition of the percolating plant, which was placed in operation during the month of January, 1912, proved a very good investment, according to Mr. Osborn. Previous to the operation of the percolator the only recovery of grease was made by pressing, so that the material when dry contained approximately 10 per cent of grease which was not recovered. During the year all solids were percolated and the yield of grease from the plant increased approximately 40 per cent.

The percolating plant was constructed at an approximate cost of $20,000, and during the year 203½ tons of grease, valued at $16,890.50, were recovered by percolation. The cost of operating the percolatory plant, including fuel, labor, gasoline and supplies, amounted to $4,601.97, making an earning from percolation amounting to $12,288.53, which is about 60 per cent. of the original investment.

OPERATING RESULTS FOR 1912 COMPARED WITH 1911

GARBAGE REDUCED, TONS

	1911	1912
January	1,063.08	1,224.64
February	977.03	1,048.87
March	1,114.75	1,172.55
April	1,175.22	1,221.91
May	1,364.05	1,373.64
June	1,371.39	1,353.52
July	1,613.47	1,808.30
Auugust	2,147.44	2,295.57
September	2,270.71	2,425.47
October	1,719.28	1,842.35
November	1,355.58	1,550.74
December	1,361.88	1,471.91
Total	17,534.49	18,789.47
Average per day	56.56	60.03

EXPENDITURES

	1911	1912
Supervision and labor	$21,680.58	$24,170.86
Coal	5,964.58	7,442.73
Electric power	1,921.45	1,305.95
Repairs and renewals	1,305.36	1,717.73
Supplies	882.26	3,163.09
Office expense	271.21	181.01
Chemical analysis	290.45	223.00
Miscellaneous	166.37	299.32
Total cost of operation	$32,482.26	$38,503.69

RECEIPTS FROM PRODUCTS

	1911	1912
Grease	$34,324.54	$42,559.52
Tankage	23,163.64	17,537.04
Hides	1,217.07	1,544.49
Miscellaneous	16.50	87.57
Total	$58,721.75	$61,728.62
Receipts over expenditures	26,239.49	23,224.93
Revenue per ton garbage reduced	$3.35	$3.29
Operating cost per ton	1.85	2.05
Receipts over expense per ton	$1.50	$1.24

The figures given in the table do not include a fixed charge for interest and depreciation. Interest on bonds amounts to 4 per cent., and sinking fund for the average life of the plant would be 3.36 per cent. As repairs and renewals are charged to operation, a fixed charge of 7.36 per cent on the original cost of $210,000, amounting to $15,456, would be sufficient. If this sum were deducted from receipts there would be an earning over and above all charges.

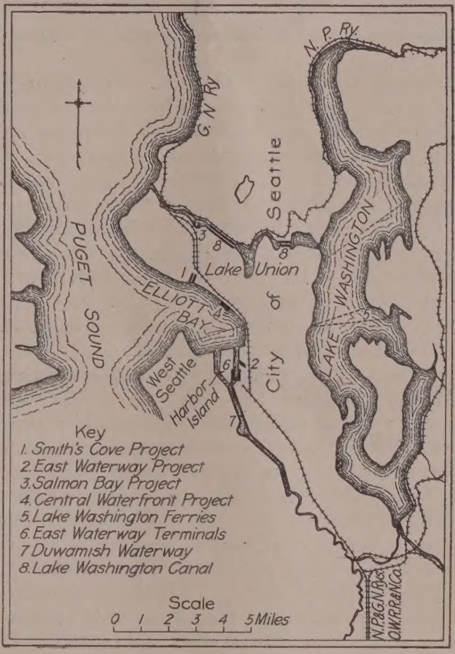
The greatest factor effecting the operation of the plant in making a comparison of the year 1911 with 1912 is the decrease in the market price received for by-products. Had the same prices prevailed in 1912 as were received in 1911 the total receipts would have been increased $13,000 with the same cost for operation.

Harbor Development in Seattle

General Outline of Six Projects Being Undertaken by the Port Commission

By William L. Kidston, Seattle

The world-wide movement for port development, ship construction, and commercial enterprise in general which promises to exceed in a single decade the total of a century past, partly as a result of the pending completion of the Panama Canal, finds vigorous expression in Seattle.



Key Map of the Various Projects

Private and corporation enterprise provided the existing port facilities. Until recently these facilities have met the needs of commerce fairly well, but the shipping of the port has of late increased at such a rate that it has grown beyond the ability of private capital to provide properly for it. The situation has been met by the creation of the Port of Seattle Commission, which has now been in existence for approximately two years. During that time a comprehensive scheme of port development has been worked out and adopted, and bonds in the sum of $6,100,000 have been authorized for the purpose of making the initial improvements, most of which are now under way.

Before determining upon the improvements that should be initiated at this time the commission thoroughly investigated the needs of the port. It was found that the Alaska, coastwise, and Puget Sound shipping was more nearly provided for than the deep-sea and Oriental transshipping business. Consequently the larger proportion of the improvements is designed to handle the overseas business, although local needs have not been overlooked.

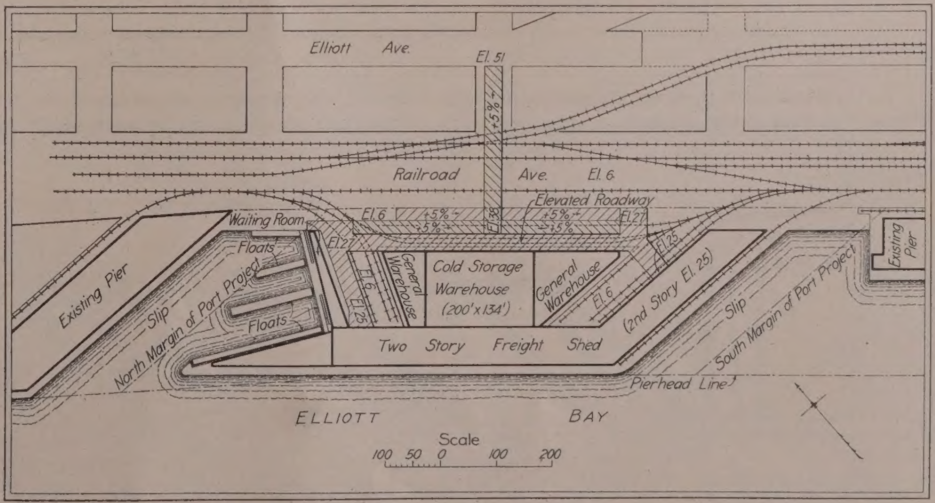
The completed program calls for the following work:

Smith's Cove project	$1,000 000
East Waterway project	850,000
Salmon Bay project	350,000
Central Waterfront project	750,000
Lake Washington Ferry	150,000
East Waterway Terminals	3,000,000
Total	$6,100,000

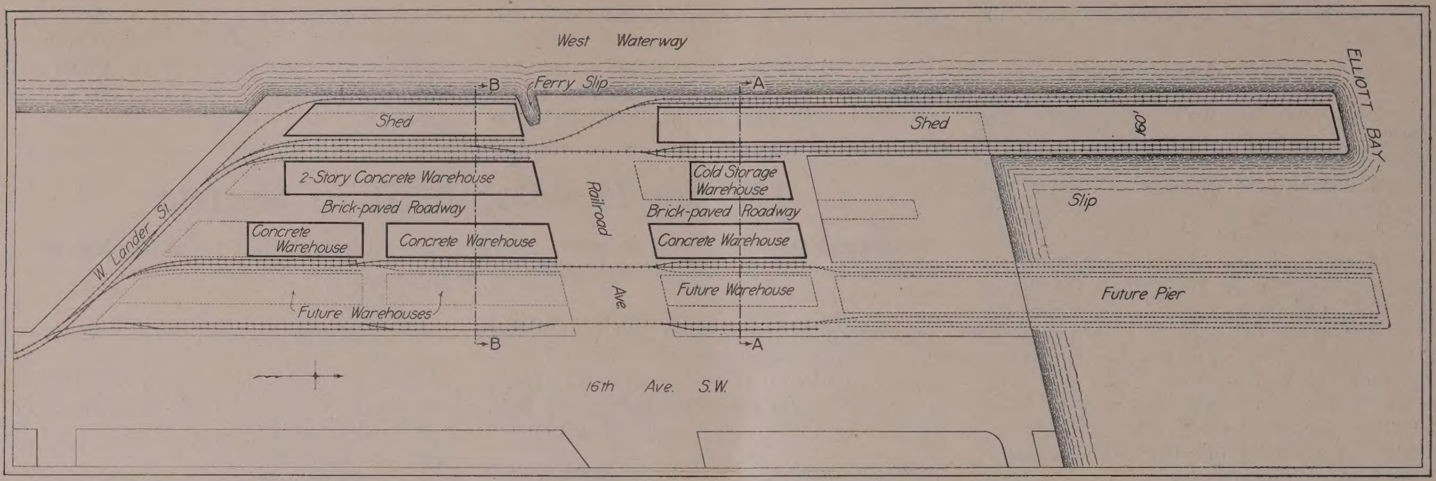
In this connection it may be noted that other harbor development is being carried on as follows by other agencies than the commission:

The straightening and deepening of the Duwamish River for a distance of 4 miles, an improvement which will give shipping facilities to, and make available for factories, a large district adjacent to the city, is under the direction of the commissioners for Waterway District 1. The contracts have been awarded and the work will cost $1,600,000.

The construction of the Lake Washington Canal, which will connect Lakes Union and Washington with Puget Sound and make accessible a non-tidal fresh-water harbor with a shore line approximately 100 miles in extent, is being carried on under the direction of the U. S. Engineers' Department with funds provided jointly by the United States



Warehouses, Tracks and Roadways in Central Waterfront Project



Arrangement of Facilities in Abandoned Harbor Island Project, for Present and for Future Development

and the local authorities, at a cost of $3,275,000. This project was described on page 640 of the Engineering Record for Dec. 7, 1912.

Projects of Port Commission

Returning to the improvements now under way or about to be started by the port of Seattle, of which Mr. Paul P. Whitham is chief engineer, they are more particularly described as follows:

Smith's Cove Project.—The general purpose of this improvement is to provide a transshipping terminal equipped to take care of the largest seagoing vessels and to serve as an assembling point for inland districts as far east as Idaho. The plans provide for a double pier with two merchandise sheds, each 680 ft. long, located at the outer or southern end of the pier and having a combined area of 149,220 sq. ft. North of these will be located two dry-lumber sheds having a combined area of 54,000 sq. ft. Between this and Garfield Street space will be reserved for lumber yards equipped with modern storage and handling devices. Adequate railroad trackage is planned for the entire pier. Contracts for the dredging and substructure work have been awarded.

East Waterway Project.—Considering the points of accessibility to the wholesale district and railroad transportation, the East Waterway between Lander and Stacy Streets was chosen for oversea docks and transshipment facilities. The work of dredging a slip 212.65 ft. in width has been started and contracts have been awarded for the construction of wharves and sheds on each side. Each shed will have a ground-floor area of 85,913 sq. ft. The plans also provide for a berthing length of 703 ft., in addition to approximately 600 ft. which will be available for local vessels at the outer end of the improvement. Plans are being prepared for a two-story concrete and brick warehouse to be located at the land end of each of the two piers.

Salmon Bay Project.—To provide suitable dockage facilities for seagoing vessels, together with landings for fishing boats and others, this improvement was designed with two slips with a central pier 980 ft. long and a fishing-boat terminal. In and along the sides of the easterly slip two lines of log floats 8 ft. wide and 1820 ft long are being installed for fishing and other motor boats.

The property will be served by railroad tracks leading from the proposed common-user tracks that will connect with the various railroads in the interbay district and with the port improvements at Smith's Cove. The result will be that this district with dock frontage at both north and south ends will have practically one terminal unit, accessible to all the transportation lines entering the city.

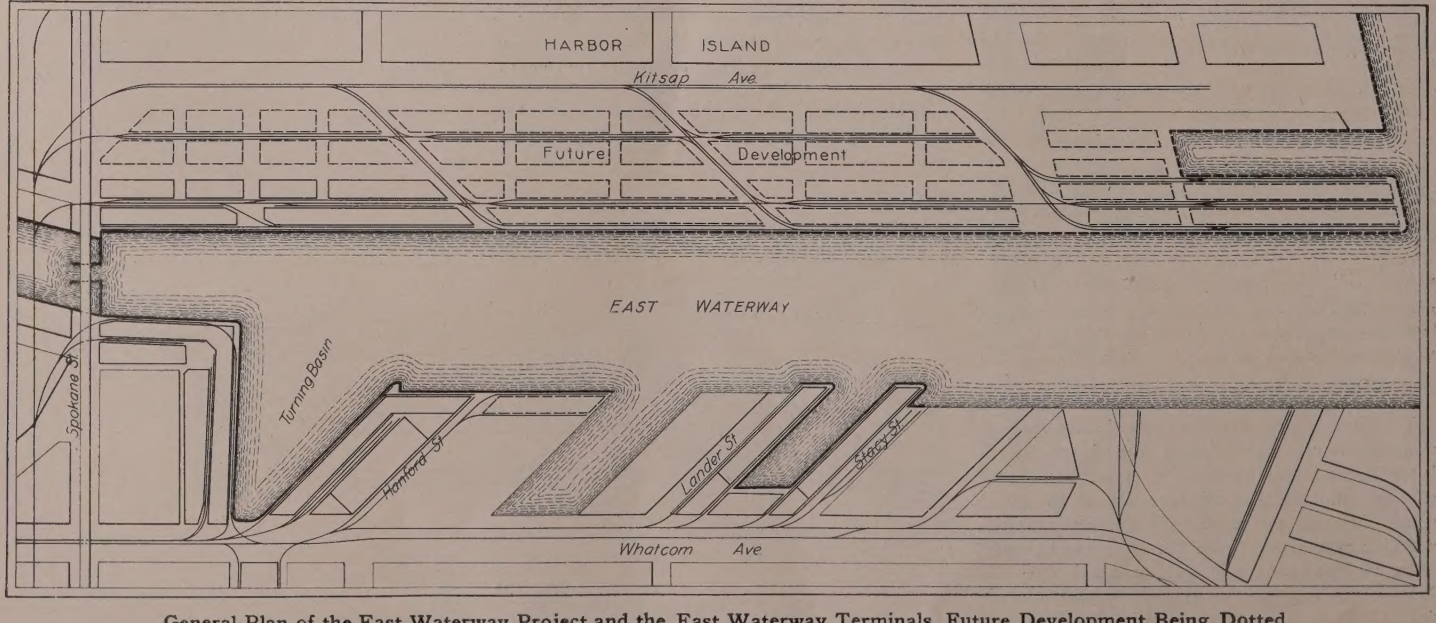
Central Waterfront Project.—The general plan of this improvement provides for a central filled area surrounded on three sides by wharves for the accommodation of local and coastwise freight and passenger vessels. It is so planned, however, that any sized vessel from a rowboat to a 600-ft. liner can be accommodated.

Of these three wharves, on which will be erected two-story sheds, the southerly dock will be 400 ft. long and the westerly one approximately 800 ft. On the northerly side a protected basin will be formed in which will be provided floats with about 1200 ft. of landing frontage, designed to accommodate market boats, fishing boats, and other motor-propelled vessels. On the filled area a general and cold storage warehouse will be erected, probably five stories high. The roofs will be utilized for recreation piers.

The conditions surrounding the construction of this improvement are ideal. It will be practically in the heart of the retail center and public markets, the latter of which derives much of its produce from the farms on the many islands adjacent to Elliott Bay and is on the right-of-way of all railway lines entering the city.

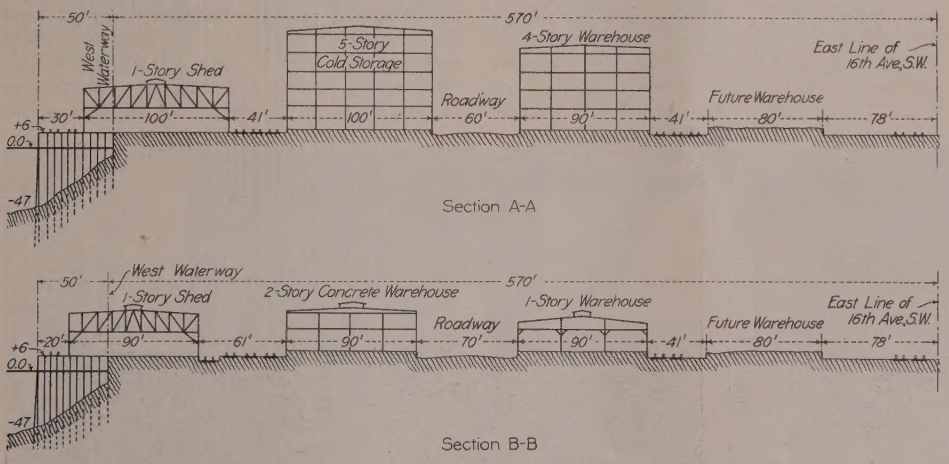
Lake Washington Ferry.—To remove the difficulty of transportation between the city and the growing country across Lake Washington, this project provides a 44 x 160-ft. steel ferryboat and three ferry slips, with wharves 200 ft. long on each side of the slips.

East Waterway Terminals.—It was originally intended to improve the west side of Harbor Island, fronting on the West Waterway. This



General Plan of the East Waterway Project and the East Waterway Terminals, Future Development Being Dotted

was known as the Harbor Island project and the appropriation therefor was $3,000,000. Details of the project are shown. After a careful study of the great foreign ports, however, it was decided to abandon the Harbor Island project and put the entire amount in one locality to make one great terminal for over-sea shipping. With this in view the electors recently voted to transfer the money for the abandoned project to the East Waterway terminals. This new development is a continuation of the so-called East Waterway project; it provides for the construction of docks from 150 ft. south of Lander Street along the east side of the East Waterway, around the end, and along the west side of the same channel to Hanford Street, as shown on the detail plan. The portions shown in heavy dashes will be improved as conditions warrant, not being covered by the present bond issue.



Typical Cross-Sections of Abandoned Harbor Island Project at Two Points

The East Waterway terminals will add 5900 linear ft. to the dock frontage, and the project also calls for the construction of one-story sheds the entire length of the improvement, back of which will be constructed reinforced-concrete warehouses of either one or two stories, having a total area of 726,435 sq. ft. Both will be served by railroad tracks as shown. The East Waterway will be dredged to a depth of not less than 30 ft. at low tide and will have a width of 850 ft. in the clear. A turning basin of ample dimensions to accommodate the largest vessels will be provided between Hanford and Spokane Streets.

On all of the projects creosoted piling is being used for wharf-foundation work in most instances on account of the low first cost. In cases where sufficient funds are available the portions of the wharves supporting the sheds are of concrete, the aprons outside where they can be easily renewed being of creosoted piling. The storage warehouses located on the ground are to be of fire-proof construction.

Summarized and classified according to uses, the projects will provide frontages of 11,256 ft. for deep-sea service, 4030 ft. for coastwise and local shipping, and 2200 ft. for motorboats and other small craft—a total of 17,486 ft., with a warehouse area of 1,442,883 sq. ft. It being borne in mind that the present dockage of all classes is approximately 48,000 lin. ft., it will be seen that the port of Seattle, exclusive of what private enterprise may do, will, upon the completion of its improvements, have added one-third to the available frontage and doubled the deep-sea dockage. The effective gain will be much greater than the figures indicate on account of the new improvements being better equipped and of a higher class of construction.

Book Reviews

The Report of the test of metals and other materials made with the United States testing machine at the Watertown Arsenal during the fiscal year ended June 30 has recently been issued. It contains the results secured in a large number of separate tests on the following twenty-one general subjects: Tensile tests on square steel wire for winding guns; tensile test of ordnance specimens; compressive tests of steel-built I-columns; tests of springs, steel castings, steel forgings, bronze, cast-iron, and gun and tool steel for ordnance work; proof tests of piston rods and chain; miscellaneous tests for ordnance work; tests of hollow deck stanchions; tests of steel specimens for comparison of testing machines; tests of cordage, manila rope and steel wire rope; metallographic examinations; tensile tests of rubber covering; hydrostatic test of gun casting; tensile tests of brown and blue-print paper; tests of anchor bolts and miscellaneous tests of steel castings; and private tests. (Washington, D. C., Ordnance Department.)

"The Panama Canal" is the title of a booklet by R. E. Bakenhus, civil engineer, U. S. N., reprinted from the U. S. Naval Institute "Proceedings," Vol. 39, No. 2, Whole No. 146, June, 1913. The preliminary historical pages go back to the discovery of the Pacific and carry the reader down through the early agitation for a canal, the attempt of the French to build the canal, the transfer of control to the United States, the investigations of routes and studies as to type of canal. The description of the canal itself comprises about 50 pages, and is illustrated with a number of photographic cuts of striking features. In the back of the booklet are a number of maps.—(Annapolis, Md., U. S., Naval Institute.)

"Hendricks' Commercial Register" has recently been issued in its twenty-second annual edition. It contains 1666 pages, a fact which gives some idea of the thoroughness of the work. There are over 350,000 names and addresses of individuals and firms engaged in building, manufacturing, contracting, engineering, and kindred enterprises, grouped under nearly 55,000 business classifications. The book aims to give a complete list of the dealers in every article and implement employed in the manufacture of machinery and industrial appliances. The index in the latest edition is so arranged that the numbers following the subjects refer to the classification instead of to the page. (New York, S. E. Hendricks Co., $10.)

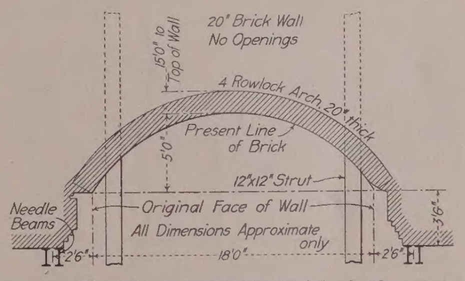
Letters to the Editor

A Question of Stability

Dear Sir: The following account of how a large brick arch is standing at the present time, with parts of its abutments entirely cut away, is a very good illustration of the remark once made by a great engineer who, in response to a query as to why a certain structure stood up, replied: "By the grace of God and the force of habit."

Extensive alterations are being made to a church situated on the west side of the city of New York, a few blocks north of 100th Street. These alterations, in so far as they have been carried out up to the present time, consist in entirely wrecking one wing of the church, in order to make way for a new addition. The wrecked wing was separated from the main body of the church by a 28-in. brick bearing wall; this wall has been left in position, except as hereinafter described. Communication between the two parts of the edifice through this wall was by means of a large opening about 18 ft. wide, spanned by a four-row lock brick arch. This arch carries not only the 28-in. wall extending for about 15 ft. above the crown of the arch, but also carries a small portion of the roof of the main part of the church.

Part of the new work to be installed consists in placing steel columns in this wall, and in order to do this the contractor has braced up part of the roof of the main building resting on the arch with long 12x12 in. strut timbers extending to the main floor of the church, has run needlebeams through the wall at various points—two sets of which are shown in the accompanying sketch—and then has cut away the wall under the needlebeam, and also under the ends of the brick arch. This is all shown in the drawing, where the original face of the wall is indicated and the present irregular faces of the brickwork are shown by heavy lines.



Sketch of Unstable Brick Arch

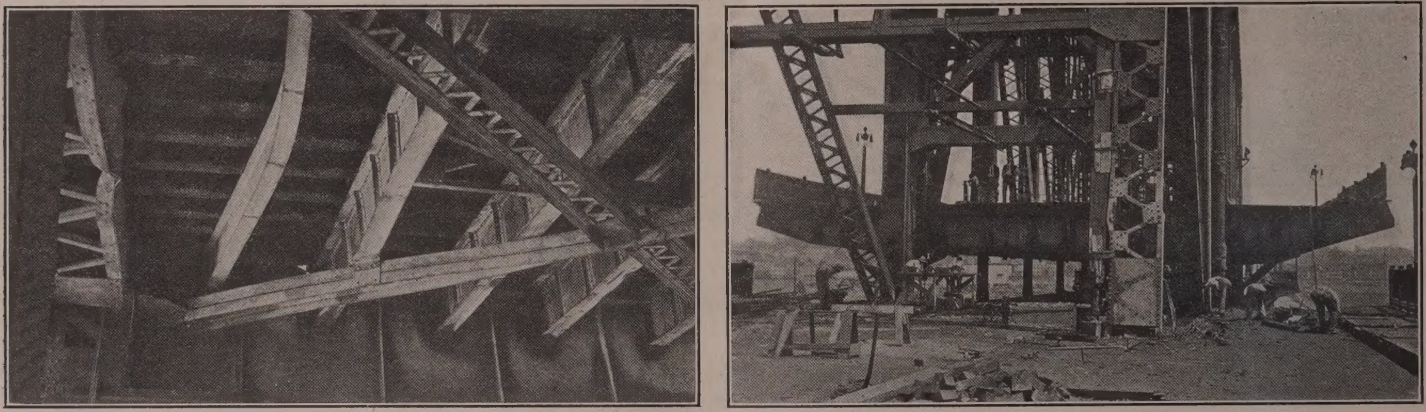
Why this arch stands is something of a mystery, but the explanation, as far as any can be given, is as follows: The brickwork above the arch is acting as a false arch, and, aided by the temporary struts supporting the roof, is carrying the load above, the true arch really being supported by this false arch; the bricks of the arch are held in position solely by the adhesion of the mortar. It is a question in the writer's mind how far such a risk should be taken, with a span of this size, even with first-class brickwork. He strongly condemns this particular case, and indeed expects any day to pass by and find this arch in ruins. It is such work as this that, when a failure occurs, brings engineers and engineering into disrepute, although if the facts were known it would probably be found that no engineer had anything whatever to do with this particular piece of work.

J. H. Gandolfo,
New York. Assoc. M. Am. Soc. C. E.

Fire Damage to New Harriman Bridge, Portland, Ore.

Dear Sir: The damage to the steel work of the Oregon-Washington Railroad & Navigation Company's bridge at Portland after a recent fire in the wooden floor, is indicated in the two photographs on this page. The bridge is the Waddell & Harrington lift type.

The picture on the left shows top lateral bracing in the end panel of the fixed span adjacent to the lift. The laced member at the lift is an extension of the top chord, which takes no dead load, but receives traction from the lift span. This member, as well as the stringers and bracings, was buckled by the expansion of the lift span. The picture on the right was taken from the fixed span looking through the tower at the partly raised lift span. The buckled member in the foreground is the back inclined leg of the tower. The flame which affected this member apparently came through an opening of about 1 sq. ft. and burned through the floor near its base.



Fire Damage to the Steelwork of the Oregon-Washington Railroad Bridge

John W. Cunningham.

Portland, Ore.

Opposition to Hetch Hetchy Water Supply

Dear Sir: I wish to correct a wrong impression given by a news item appearing in the current News Section of the Engineering Record of July 12 regarding the opposition which has developed to San Francisco's attempt to secure a municipal water supply from the Hetch Hetchy. The erroneous statement is made that: "The chief opposition has thus far come from the 'nature lovers,' but the general impression is that they have not made a strong case."

Doubtless with conscious purpose San Francisco has attempted to create just exactly that impression, that the chief source of opposition to her project were the "nature lovers," for in all the press comment by San Francisco papers during the controversy, reference to the opposition on the part of the Irrigation Districts has been studiously avoided and only that coming from the so-called "nature fakirs" mentioned.

But the chief opposition to San Francisco's demands has not come from the "nature fakirs." Her encroachments upon the water supply of the Tuolumne River watershed, of which the Hetch Hetchy is a part, have been most violently and most effectually opposed by the riparian land owners of the Tuolumne River and owners of other semi-arid lands contiguous thereto who felt that their rights to the cheapest and best source for an irrigation supply were endangered. That opposition has been led by the Modesto and Turlock irrigation districts and the County of Stanislaus within which a large portion of the lands dependent upon the Tuolumne River lie. And the Chambers of Commerce of practically all counties of the south-central portion of California have made the cause their own and lent their assistance by telegraphing and mailing protests to their representatives in Washington.

These protests are based upon the following contentions:

1. The waters of all streams tributary to the San Joaquin River are needed for the proper development of the semi-arid lands lying within that valley and the diversion of any amount of water therefrom to an outside party means that a proportionate part of the San Joaquin Valley must forever stop short of its proper development.

2. The known monthly mean discharge of the Tuolumne River has on some years fallen as low as 1352 sec.-ft. and during the past year it has doubtless fallen much below that figure, for since the Modesto canal opened its head gate on Dec. 1, 1912, after the completion of its full repairs, the two districts have utilized practically all the flow of the Tuolumne River and then been short a considerable portion of the time. The two districts (Modesto and Turlock irrigation districts) have a combined area of approximately 260,000 acres of which only about one-half is at present under irrigation. For this acreage the combined diversion amounts to something like 1900 sec.-ft. The irrigated acreage is increasing at the rate of about 10 per cent per year and the capacity of the canals and other works is being increased as rapidly as possible to keep up with the increased demand for water. In addition surveys have been made and steps been taken to organize another irrigation district to be known as the Waterford irrigation district which will lie between the Modesto district and the headgate of the Modesto canal and will draw its water supply from the Tuolumne. While just across the San Joaquin River from the Modesto and Turlock districts lies another vast area which is clamoring for water and will find the Tuolumne River a most practical source, if there is any to spare. These districts now formed or in process of formation appreciate the necessities for storage and are proceeding faithfully to provide for it. They feel that the need should indeed be a crying one which would permit a distant city to encroach upon their water supply and leave the lands dependent thereon for a proper development parched for want of water throughout all time to come.

3. San Francisco herself does not claim that she is dependent wholly upon the Tuolumne for a water supply. Besides a possible supply by pumping, San Francisco, at a cost of slightly, if any, in excess of that for the Hetch Hetchy, may go to the McCloud River or other tributaries of the Sacramento. By so doing she would imperil the development of no land whatever, for the Sacramento watershed has water to spare.

To back up these contentions the two districts have given liberally of their time and money. At least $7,000 has been spent in actual cash (and only those who have had experience in securing appropriations from boards of farmer directors can appreciate what this means). A large corps of engineers and assistants were employed for several months preparing a report of some 130 pages with accompanying tables and diagrams which was presented to the Secretary of the Interior to inform him as to the needs of the Districts. Twice delegations of engineers and attorneys have been sent to Washington to attend the hearings there and oppose San Francisco.

The provisions of the Raker bill, as finally adopted by the committee for the consideration of Congress, are the best possible terms the irrigationists could wring from the proponents of the Hetch Hetchy water supply and are most eloquent evidence of the source from which came the chief opposition thereto. It was from land owners who feared history would repeat itself in another case similar to the one which gave Los Angeles a water supply at the expense of the farmers of the Owen's River Valley instead of from "nature fakirs" that the chief opposition to San Francisco came.

Modesto, Cal. Everett N. Bryan.

[The recent hearings before the House Public Lands Committee, to which the item in the issue of July 12 referred, was on the Raker bill, which the irrigation interests have accepted even if they are not entirely satisfied. It was proper, therefore, in speaking of these hearings to say that the chief opposition to the bill had come from the "nature lovers." The opposition of the irrigation interests previous to the close of Secretary Fisher's term of office was duly recorded in the items published by the Engineering Record regarding the Hetch Hetchy controversy.—Editor.]

The Eight Steel Cantilever Cranes used in handling practically all of the concrete for the Pedro Miguel and the Miraflores locks have been offered for sale, according to the "Canal Record." Bids for them were opened July 14, it being expected that all of them will be out of service in the canal construction by Sept. 1.